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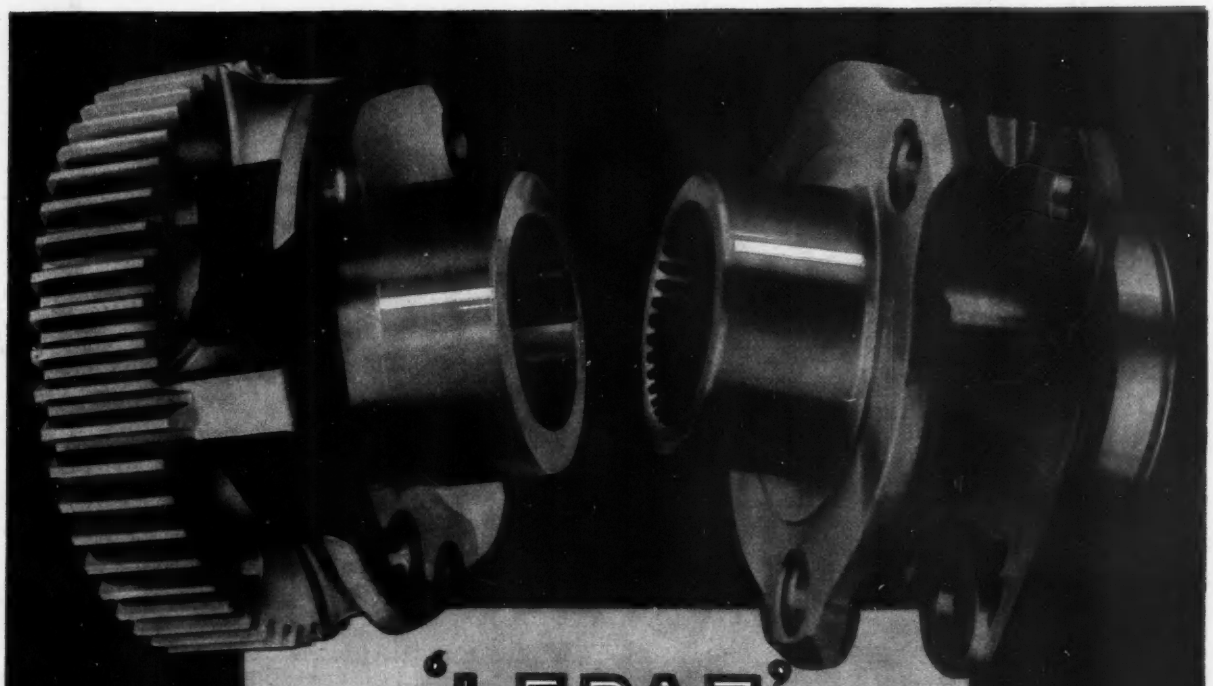

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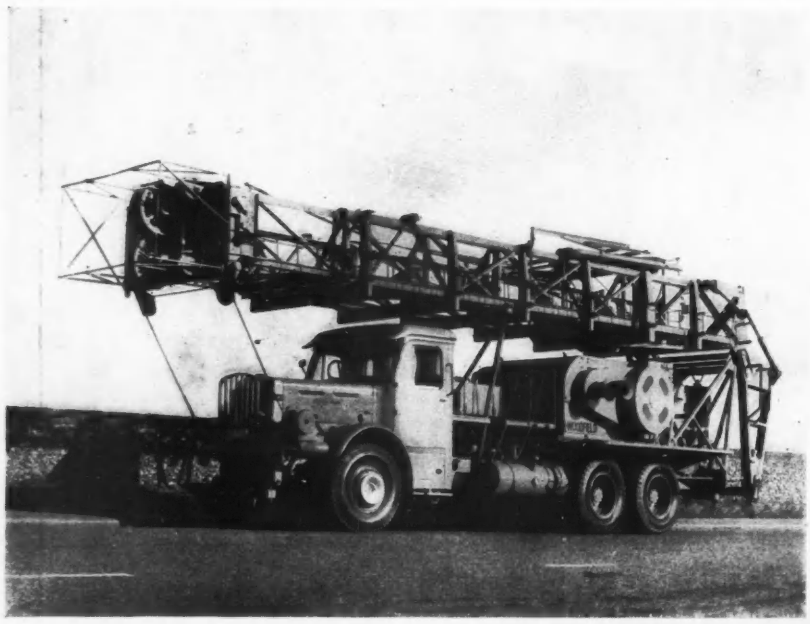

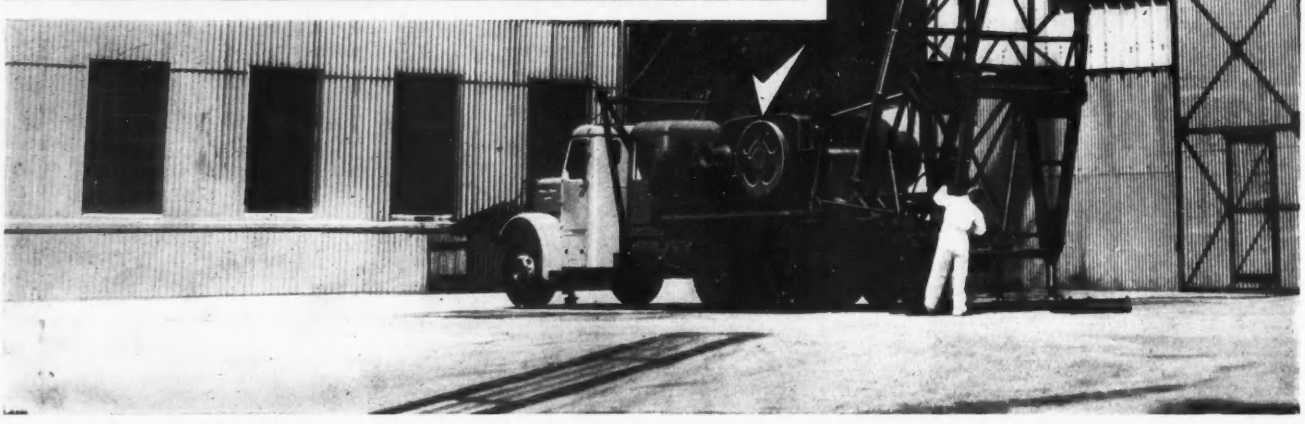

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THE ENGINEER

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Telephone: CENtral 6565

Vol. 204 No. 5318

DECEMBER 27, 1957

Published every Friday Registered as a Newspaper

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January 9	Miscellaneous stores, including :—	General Stores Sub-Depot, Longtown, Nr. Carlisle. (Sale at County Hall, Carlisle.)	HARRISON&HETHERINGTON, LTD. (Dept. L), Botchergate, Carlisle. (Tel.: 26292/3.)

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January 13–15	Vehicles, motor cycles miscellaneous stores, &c.	Central Ordnance Depot, Bicester, Oxon.	MIDLAND MARTS, LTD. (Dept. L), Market Square, Bicester, Oxon. (Tel.: 73.)
January 21–24	Vehicles, cranes, earth moving equipment, motor cycles, &c.	M.O.S. Storage Depot, Ruddington, Notts.	WALKER, WALTON & HANSON (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 47271.)
January 21–22	Miscellaneous stores, including blankets, tentage, engineers' hand tools, chemicals, &c.	Central Ordnance Depot, Didcot, Berks.	SIMMONS & SONS (Dept. L), 12, Station Road, Reading, Berks. (Tel.: 54025.)

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LORD RUSSELL AND THE BRAINS TRUST

Even when we hotly disagree with its conclusions, the B.B.C. Brains Trust invariably invokes our sympathy. Seldom have we more flatly disagreed than with one of its conclusions last week; and never have we felt more sympathy for it. It is asking a lot of a panel that it should have thrust at it a variety of questions which must be discussed, immediately and without opportunity for serious thinking, before an enormous and no doubt often critical audience. But it is asking far too much when the panel has read to it two sentences, out of context, from a recent talk by Lord Russell, and is asked to comment! For, if the full wealth of meaning behind any statement by Lord Russell is to be absorbed, time for digestion is usually needed. The two sentences quoted to the panel were: "If Homer and Aeschylus had not existed, if Dante and Shakespeare had not written a line, if Bach and Beethoven had been silent, the daily life of most people in the present day would have been much what it is. But if Pythagoras and Galileo and James Watt had not existed the daily life not only of Western Europeans and Americans but of Russian and Chinese peasants would be profoundly different from what it is." The full text was recently printed in the *Listener* and that part of the text which contains these sentences was reprinted in our issue of December 13.

Given no time for contemplation, the Brains Trust saw in the words something which is not there. They rushed headlong to the defence of Homer, Aeschylus, Dante, Shakespeare, Bach and Beethoven; and they were even a little rude to Pythagoras, Galileo and James Watt, suggesting disparagingly that had these people not made their discoveries someone else certainly would have done! If in those words we exaggerate what they said, we hope for forgiveness. For we confess we, like they, were labouring under difficult circumstances. We were listening in the midst of a family circle only too willing to offer its own comments upon the matter under discussion! Yet it did appear to us that the panel exaggerated the importance of the moral and artistic vision of those they defended and that they came perilously close to the indefensible idea that even material advances flowed ultimately from that vision. Yet it is, in fact, difficult to believe that great writers, philosophers, artists and musicians, or even such a man as Karl Marx (who was mentioned by the panel), have really had much influence upon the long series of discoveries which have raised the material richness of the human race. The boot is rather upon the other foot! Those men who have contributed to the material progress of the human race have provided for philosophers, artists, humanists and sociologists a constantly changing scene for the preaching in new forms of fundamental human truths. We may be wrong, but it seems to us that those periods of human history in which material progress has been more or less static are not particularly notable for the flowering of human genius in any form. It is when the technologists and innovators are changing the material foundations of society and thereby creating a turmoil, that philosophers and sociologists flourish and artists conceive revolutionary methods of expression. The truth, of course, is that a healthily advancing society throws up men of both kinds. Both are necessary to forward the advance. Lord Russell did not deny it. He was not attacking humanists and artists. In speaking the sentences quoted he was merely illustrating two differing ways of estimating the worth of a human achievement. Particularly, he was not rude to materialists. For those who have made a study of science do not leap to the erroneous conclusion that because its practitioners are concerned with facts and with mathematics the whole affair is arid and soulless. The conception of such a hypothesis as, for example, universal gravitation, is as creative an act as the composition of a great musical sonata. Every engineering designer is exercising an art just as fully as is a painter or a sculptor.

Disparagement of the work of scientists and technologists arises out of the unfortunate dichotomy that grew up—largely, we think, in the nineteenth century—between those subjects of the one hand and the arts and the humanities on the other. We often wonder whether it is appreciated by those who know little of science and technologists that, erroneously, they often believe, contemptuously, the artist to be so wholly ruled by emotion that he is incapable of coherent thought; just as artists are too easily misled into thinking scientists to be soullessly ruled only by

reason. We would rather have seen the Brains Trust attempting to break down this dichotomy than contributing to its retention. But, as we remarked at the start, our sympathies remain with the panel. Unless they had been familiar with Lord Russell's talk it would have required the arts of a magician to set their thoughts musing upon more satisfactory lines. Alone and without context it was easy for them to misread into the two sentences something other than the truth which Lord Russell was expressing.

TRADE WITH CANADA

The sending by Canada of a trade mission to this country has proved a resounding success. The members of the mission have gone back to Canada immensely impressed by what they have seen and convinced that there can be a great expansion of trade with this country. Already they are making arrangements to ensure that importers, potential importers and users in Canada shall be fully informed. The ball is now with British manufacturers. The Canadians desire to import more from Britain. To judge by the hundreds of British manufacturing firms which insisted in one way or another upon getting into touch with the mission or with individual members of the mission, and the further large number which, despite efforts to do so, was disappointed, there is a strong desire amongst British firms to supply the Canadian market. A mission from this country is to go to Canada next spring to examine opportunities available and to see what other activities can be undertaken to improve Britain's public relations, marketing, and so forth, over there.

But though immense goodwill has been generated the British manufacturer cannot expect, as a consequence of the success of the mission, to find that he can walk easily into the market and obtain orders. In 1939, Britain supplied Canada with 18 per cent of its total imports. But mainly as a consequence of the war and of the need thereafter to rebuild Britain's industries, Canadians had, during the war and the post-war years, to turn to the United States for much that they needed. In 1956, Britain supplied only 8½ per cent of Canada's imports. The Canadian market has become accustomed to the methods of American makers in the styling and presentation of many goods. Perhaps, more importantly in its effects upon engineering firms in this country, it has become accustomed to American engineering and other "Standards," the more so that many Canadian companies are American controlled. Furthermore, as compared with the United States, divided from Canada by an undefended line across the map and linked with it by road, rail, air, and transport by ship across the Lakes, Britain is some 2000 miles away. True, the opening of the St. Lawrence Seaway from end to end within a couple of years will help to belittle the difference. Yet if trade is to be built up in Canada, Britain will need to take a variety of actions to build up stocks of spares and provide for immediate maintenance of engineering plant supplied,. To combat the variety of forms in which American advertising reaches Canadians heavy expenditure may be needed in that field. Strongly, therefore, though many smaller firms in this country may feel a desire to enter the Canadian market, they may hesitate to embark upon the project. For they may feel that the expense of surveying the possibilities, of establishing a selling procedure, of building up stocks and of persisting, perhaps at some considerable loss, in striving to obtain orders over a period that may extend into years, is beyond their resources, however profitable it can be expected eventually to be. That point has been grasped in this country. The Dollar Exports Council is to take action. It intends to select, to begin with, some half-a-dozen men who are successful, but relatively small, exporters to Canada, and ask them to act as leaders of groups of firms to which they can give guidance and assistance. The idea appears to be that the firms so grouped will not be in competition with one another to supply similar goods, but complementary, as, for example, in the supply of goods all of interest to a particular industry or applicable to particular kinds of project. The Dollar Exports Council will also suggest to certain larger exporters of goods to Canada that they should accept agencies for the sale of products of smaller prospective exporters. Additionally it will, in the months and years to come, be taking other action. Thus, as the Canadian Mission goes home, taking with it the best of Christmas wishes from this country, activity will be gathering momentum in this country to see how far the object of the mission, to expand inter-U.K. and Canadian trade, can be pushed in the future.

THE ANNOYANCE OF NOISE

This is the season when columnists and commentators are accustomed to give their impressions of a walk through the City of London—or some other big city—during the afternoon of Christmas Day. The silence of the streets, they tell us, is something that provides a striking contrast to the clatter and din which the modern workaday world has to bear. But noises of one kind and another, whether they derive from traffic on land and in the air, from machinery at work, or from "music while you work" have become so much a part of the normal run of life that most folk are apt to feel the miss of them when they are absent for a brief space! It may be that we have said too readily that noise is a pestilence that cannot be cured and must therefore be endured. Consequently, there are those in almost every walk of life who have schooled themselves to work, to play, to eat and drink and even sleep amidst a cacophony of sounds.

But that noise, and especially noise in industry, is a menace, few would deny. For many years past, the deleterious effects of noise have been studied by medical and psychological researchers; for many more years past there have been periodic protests about the increase of noise, which have frequently been coupled with the complaint that nobody seems to be able to do anything about it. We find, for example, that nearly a hundred years ago, in these columns, in some comments on the health of engineering workers, we saw fit to explain that though boilermakers were a healthy set of men, they suffered "principally in their sense of hearing, getting more or less deaf, sooner or later, through the continued noise amidst which they work." Yet the only remedy we were able to suggest at that time was that "a good deal of the injury to the sense of hearing would be prevented by the use of a little cotton wool, against the fine threads of which the waves of sound would break before striking the tympanum." Since then, happily, technical progress in the design of many kinds of machines has not overlooked the importance of noise abatement.

Nevertheless, whether or not we choose to accustom ourselves to it, noise continues to be a menace. Its reduction remains a problem which engineers must persistently attempt to solve. Quite recently, *Target*, a Government-sponsored sheet aimed at the promotion of better productivity, has made an investigation of the menace of noise in industry. The findings from that investigation are before us. The principal among them seems to be that "techniques for the reduction of noise and vibration in machinery have been fully developed, and excellent results may be obtained if a strong desire to achieve these is in the mind of the engineer." It is a praiseworthy deduction, the more so as there is a rider which urges that "competent organisation" can do much to abate the noise nuisance. The investigators, however, are evidently not unduly optimistic about competent organisation, for they have felt compelled to add that "when this is impossible ear protectors are recommended for the use of exposed employees!" As we ponder upon the Christmas quiet of factory and street, we are certainly ready to agree that noise is often annoying. At the same time, we are by no means sure that, in general, its abolition—should that ideal be reached—would add a great deal to efficiency. Nor perhaps to happiness. The house will become sadly quiet in four weeks' time when the children go back to school!

A Seven Day Journal

First Fleck Report on Windscale

THREE committees were formed under the chairmanship of Sir Alexander Fleck to recommend what remedial action should be taken by the U.K. Atomic Energy Authority following the accident at Windscale last October. One of these, the Organisation Committee, has now completed its report and this has been published as a White Paper (Cmnd. 338). The Health and Safety Committee has also nearly finished its investigation and is considering the draft of its findings, but the Technical Evaluation Committee has not been able to do more than promise a brief interim report to the Prime Minister soon after Christmas. Sir Alexander states in his covering letter to the White Paper just issued that, because of experimental work to be carried out, calculations to be made and changes to be initiated, it is impossible to contemplate starting No. 2 pile (the accident occurred on No. 1 pile, but No. 2 has been shut down since) earlier than the middle of 1958. More information should be available by next March, however, and he hopes that his third committee will then be able to submit a full report.

The conclusions of the White Paper, briefly stated, are that the organisational weakness of the U.K.A.E.A. Industrial Group stems " primarily and noticeably from an insufficiency of senior technical staff," and that to correct this situation a number of new senior technical posts will have to be created. " Where the men to fill these posts will come from," says the report, " is a matter for the Authority." It is considered that unless substantial recruitment of high-quality staff is successful, strengthening of the Operations Branch at a lower level will be necessary at the expense of some work at present under way elsewhere in the Authority. But this work must not be wasted, it is acknowledged, and since " panic measures " are not required, " the necessary transfer of staff can only take place with due deliberation over a period of time."

Bus Electronic Scanning Indicator for Running Control

IN its efforts to improve regularity of its bus services, London Transport is developing an electronic system for providing, at a central control point, accurate information about the position of individual buses along a particular route at any given time. A route controller at a central control point can thereby ascertain without delay whether any congestion has built up in any area traversed by the bus route in question. The system, known as Bus Electronic Scanning Indicator (B.E.S.I.), is now undergoing field trials on the 74 bus route. Electronic-optical equipment is being installed at check points on the route, whereby the number of each bus is read as it passes the scanner, and is then encoded electrically and transmitted over telephone wires to the central control, where it is displayed on a panel and recorded on a chart. As each bus passes the next check point on the route the number of the bus is recorded on another panel and cancelled on the first. In effect each panel indicates the running number of each bus on the section of the route bounded by two check points.

Each bus running number has been encoded into a binary number and has been reproduced on a plate by mounting thereon " cats eye " reflectors for each digit and a corresponding blank for each zero. Each bus has this plate mounted on the near side above the driver's cab, at a height of about 8ft 6in. At the same height scanning equipment has been mounted, preferably on a post at the pavement edge. The scanner consists essentially of a source of modulated light focused on to the plates of the buses and a suitable optical system to receive the reflected light. As each reflector on the plate passes across the beam of light, the reflected beam strikes a photo-electric cell, giving an intermittent current wave modulated by the light source. The signals are filtered out, amplified and formed into a wave shape suitable for transmission over the connecting telephone wire. At the control point the signals received over the telephone wires operate relays which build up the binary number of the bus, and close the appropriate circuit, to cause the actual running number to be illuminated on the check-point display panel.

B.E.S.I. is believed to be the only system at present in use for giving automatic indication of the position of individual buses at any given time. The system is to be installed over the whole of the No. 74 bus route by next spring, for extended field trials.

The Engineer

100 Years Ago

(DECEMBER 25, 1857)

" GLASS-COVERED THOROUGHFARES "

" Ever since the construction of the Crystal Palace, in 1851, there have arisen numerous advocates for the formation of streets or avenues, in the metropolis, covered in with glass. Sir Joseph Paxton himself, elated at the success of his design for the Great Exhibition Building, was not long in devising one of the most extensive and most impracticable plans for roofing in a great part of London which could well be imagined. We say nothing against the taste displayed by the glass architect in his designs, or that it would be impossible, physically, to work out his views ; but, considering the limited nature of our means for carrying out in London what is absolutely necessary, in order to render it tolerably healthy to live in, namely, its proper drainage, Sir Joseph's plan may be fairly said to be perfectly impracticable. . . . . The proposition of Sir Joseph has, however, not been without its beneficial effects ; for we are now upon the point of having a first instalment of what has been so much admired in continental towns, but of which we have hitherto in London seen little, namely, a glass-covered public thoroughfare or arcade, in which flowers and fancy articles will be sold.

" The new experiment, which is about being tried in the formation of such a place as we have described, is that of a glass bazaar or arcade in connection with the new Italian Opera House, Covent Garden, which is now in course of erection on the site of the old theatre. The area formerly occupied by Covent Garden Theatre has been considerably enlarged . . . . . the whole space now to be devoted to the new opera house and the glass bazaar exceeding an acre in area. The southern portion of this space is that intended for the formation of the glass bazaar, which will be some 250 feet in length and 80 feet wide. The entire structure will be of iron and glass, having a semi-circular roof, and an entrance at each side at either end. . . . . We have been induced to notice this public improvement, as we think it is the first step which has been taken in the right direction towards the formation of covered thoroughfares in London of such a character as to make them popular lounges. . . ."

Trade with Canada

LAST week, the members of the Canadian Trade Mission returned home after a very busy month's stay in this country. On the eve of their departure they met representatives of the press at a conference arranged by the Dollar Exports Council. A statement prepared by the Hon. Gordon Churchill and Mr. J. S. Duncan, chairman and vice-chairman, respectively, of the mission, said that in their visits to a number of United Kingdom industries, both large and small, the members of the mission had been favourably impressed. They felt that, speaking broadly, British industry was showing leadership of a high order in its scientific research, its new technologies and in the efficiency of its manufacturing practices. They had been likewise impressed by the knowledge, ability and leadership of the senior personnel in the manufacturing plants visited, from the foreman level upwards, and particularly by the skill, artisanship and productivity of the workers. In all the plants visited, the housekeeping was excellent, and, the statement added, good housekeeping was always an indication of good manufacturing practices. There was no doubt in the minds of the members of the mission that many of the things which Canada was at present importing from elsewhere and predominantly from the U.S.A., could be supplied by the United Kingdom to " a substantially greater degree."

At the same conference, Sir William Rootes, chairman of the Dollar Exports Council, said that a major consequence of the mission's tour would be an active " follow up " in Canada by a large proportion of the British exporters visited. As part of that follow up, the Dollar Exports Council would send a small but strong return mission to Canada next spring. The mission, Sir William continued, had urged that more attention should be given to the formation of exporters to Canada into groups for selling purposes. The Dollar Exports Council intended to select men, who were successful but relatively small exporters to Canada, and ask them to accept appointments as the leaders of groups to be formed round them. There would be no difficulty in preparing lists of exporters likely to benefit from membership of such groups once the experienced leadership had been established. The Council had also determined, Sir William said, to discuss arrangements with some of the larger United Kingdom exporters to Canada, with sales and warehouse facilities already established there, with a view to their accepting agencies for some of the smaller exporters.

Influence of Coriolis Forces on Heat Transfer in the Open Thermosyphon

By B. W. MARTIN, M.Sc., Ph.D., and D. J. CRESSWELL, B.Sc.*

To increase the scale of application of the gas turbine in the field of industrial power production its thermal efficiency must be substantially improved. This is most easily achieved by raising the maximum cycle temperature, thus necessitating some form of blade cooling. The thermosyphon, using hollow blades and a fluid reservoir in the rotor drum, is a promising method of cooling rotor blades. A vertical static tube has already been used to study the heat transfer characteristics of the open system (Martin 1955), but the effect of Coriolis forces must be ascertained before attempting to translate the findings to turbine operating conditions. In the work to be described, these forces (which derive from the combined radial and circumferential movement of the fluid particles) are simulated in a fundamental approach using an inclined static tube. The results show that the resultant transverse forces exert an effect on the flow regimes and heat transfer which is generally appreciable and is governed at least in part by fluid Prandtl number. When this is near unity, as in the above application, Coriolis forces appear to retard the development of fully-mixed turbulent flow and thus improve the heat transfer.

IF the turbine inlet temperature of the gases in a gas turbine plant can be substantially increased, considerable improvements are possible in both thermal efficiency and specific output (Brown 1954, Rohsenow 1956, Martin 1957). At the present time, the maximum permissible gas stream temperature is limited to values below 1500 deg. Fah. because this is the extreme working temperature of the heavily-loaded rotor blades. The use of higher operating temperatures, in the range 2500 deg. to 3000 deg. Fah. will depend on the rotor blades being effectively cooled to, or otherwise maintained at, working temperatures in the vicinity of 1400 deg. Fah., since it is unlikely that metallurgical advances will lead to any sudden and large increase in this order of temperature.

One form of blade cooling is by the open thermosyphon system. This consists in principle of a heated tube, closed at one end and open at the other, filled with fluid, which is subjected to an axial acceleration acting towards the closed end. Thus heat is removed from the tube by the fluid under the influence of free convection. A heated annulus of fluid next to the tube wall moves towards the open end where it is discharged into a reservoir. This is simultaneously replaced by a central core of cooler fluid entering the tube from the reservoir. In this way, a circulatory system is set up ; the acceleration may be due to gravity, as in the case of a static arrangement, or it may be a very effective artificial gravity created by rotation. The effectiveness can be gauged from the fact that it may well reach 30,000 times normal gravity, when the system is used in a turbine for blade cooling. Each rotor blade would have a blind-ended radial passage communicating with a reservoir of fluid (common to all the blade passages) in the rotor drum.

Holzwarth (1938) was the first to suggest the open thermosyphon for gas turbine rotor blade cooling, and a four-stage turbine incorporating this method was designed by Schmidt (1951) and built in Germany in 1943. After some initial successful runs certain mechanical difficulties (connected with vibration and coolant flow control) arose which prevented further tests of the cooling system. In 1951 Ellerbrock published the results of some tests on a turbine with coolant passages in the blades, in which he found that the Nusselt number (based on passage length) was practically constant at 400 over a range of Rayleigh numbers from 10^{12} to 10^{14}, again based on passage length.

A number of tests carried out on a vertical static rig using various convective fluids and tubes of differing length—radius ratio were reported in papers by Martin and Cohen (1954) and Martin (1955). This work confirms a great deal of Lighthill's theoretical analysis (1953), particularly for laminar flow, but the more tentative theory for turbulent flow does not agree too well quantitatively with experimental findings. Hartnett and Welsh (1956) have also studied experimentally certain aspects of heat transfer in the static open thermosyphon, and on the basis of average performance report agreement with the observations made by Martin. In the gas turbine application, Rayleigh numbers are expected to range from 10^{11} to 10^{15}, based on passage length. In this range, the dominant regime is expected to be fully-mixed turbulent flow, in which the cooler entering fluid is believed to be turbulent from the point of entry, and to mix quite readily with the hot fluid near the tube orifice. This reduces the heat transfer, compared with a boundary-layer regime.

However, when the thermosyphon is used for blade cooling, it is clear that while the coolant is moving in the passage along the length of the blade it is also rotating with the blade. Each fluid particle is therefore subjected to a Coriolis component of acceleration, which acts at right-angles to the blade axis. The resultant acceleration on the particle is thus at an angle to the blade axis, being the vector addition of the centrifugal and Coriolis accelerations. This was pointed out by Alcock (1951) and Jendrassik (1951), and Alcock suggested that the effect might be simulated qualitatively by tilting a static rig. In this case, the total acceleration is still that due to gravity, but it now has one component along the tube axis and a second component at right angles to the axis. The relative proportions of these two components are, of course, determined by the angle of inclination of the tube axis to the vertical.

It is evident from the foregoing that some knowledge of the effect of Coriolis forces on the heat transfer is essential before results obtained from static tubes can be applied with anything like certainty to blade cooling problems. The authors do not know of any previous attempt to isolate and thus to ascertain the effect of Coriolis forces (although they are aware of work on inclined parallel plates by Elenbaas (1942), and on inclined open tubes by Koch (1927), which they consider to be a different problem) and the present paper describes an investigation carried out on an inclined static rig. In attempting to evaluate the effect of Coriolis forces, this technique has certain limitations which are outlined below but which are not considered sufficiently serious to invalidate the conclusions drawn from the tests.

The alternative approach is to use a rotating test rig and this may at first sight appear more attractive because it is more realistic, but it carries many problems in connection with reliable heat and temperature measurements. Another objection is that, since with such a rig Coriolis forces can never be independently controlled or eliminated, it is impossible to measure the effect they have on the heat transfer characteristics of the static system, or even to determine probable trends, though, of course, a rotating rig does yield the actual heat transfer when Coriolis forces are operative. But from the point of view of fundamental study this is hardly adequate. The possibility of developing a theoretical solution cannot be overlooked, though this is unlikely in view of the extreme complexity of the problem and the existing disagreement between experiment and the most recent theories of turbulent flow in the vertical thermosyphon.

In a rotating passage the hot and cold fluids move in opposite directions and therefore the Coriolis forces also act in opposite senses. The resultant tendency is for the hot and less dense fluid to be concentrated at the leading edge of the blade passage and the cool and denser fluid to move towards the trailing edge. But in the static rig only the force on the *cool* fluid is simulated. This limitation is probably not so serious if the flow is turbulent and fully-mixed as in the case of a boundary-layer flow regime, where the two streams are clearly separated. Furthermore, the Coriolis acceleration is proportional to the velocity of a fluid particle along the tube, and therefore varies until it becomes zero at the closed end. In the static rig the simulated Coriolis acceleration is constant along the length of the tube. Also, in a rotating passage the centrifugal acceleration is proportional to the distance of the particle from the centre of rotation, while the component of gravitational acceleration along the tube axis is constant in the static rig.

In the present tests ethylene glycol and water were used as convective fluids in order to obtain information about the effect of Prandtl number. Tests were conducted on both fluids at six angles of inclination from 0 to 45 deg. Only one tube was used of length-radius ratio 15 ; this was the smallest value with which fully-mixed flow had been obtained by Martin, using the above fluids. It is also a value typical of those likely to be used in blade coolant passages. In the static rig the passage dimensions are scaled up to compensate for the numerical difference between the accelerations involved. This permits the Rayleigh numbers reached in the static tests to approach the values expected at turbine operating conditions.

Apparatus and Procedure

The thermosyphon tube is a brass cylinder 15in long, 2in internal diameter and $\frac{1}{8}$in thick. The tube is heated by "Pyrotenax" resistance wire wound into a spiral groove cut on the outer surface of the tube. The heater is in two sections encased in white metal to ensure good contact with the tube when the temperature is raised. The tube was originally constructed by Shen (1948) under the super-

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vision of Mr. E. J. Le Fevre for an earlier study of free convection, but has been considerably modified for the present investigation. Fig. 1 is a general arrangement of the apparatus, while the photographs of Fig. 2 show the thermosyphon in both vertical and inclined positions.

Four copper-constantan thermocouples are buried in the inner wall of the tube, all flush with the surface and in the same vertical plane. They are arranged in pairs, one pair being 2in from the open end and the other pair the same distance from the closed end. Each pair is located at opposite ends of a diameter situated in the above-mentioned vertical plane. This plane is perpendicular to the horizontal axis of rotation when the tube is mounted in the rig. It is, therefore, possible to measure temperatures at positions along the tilted tube corresponding to the "leading edge" and the "trailing edge" of a cooled turbine rotor blade. It is important that the range of temperature variation around the inner surface of the tube should be known; it is, of course, zero with the tube vertical because the fluid flow about the tube axis is then symmetrical, but this condition ceases when the tube is tilted and symmetry is destroyed. There is then a temperature variation round the tube. The underside of the tube, where the cool fluid is concentrated, will, by analogy with a cooled blade, be referred to as the trailing edge, and the top side, at the higher temperature, as the leading edge (Fig. 1).

The brass cylinder is constrained by end discs to be concentric with a copper outer tube 6·5in external diameter. The annular space between the tubes is filled with granulated cork to minimise heat losses, and the copper tube has a thermocouple on its inner surface. The lower end of the thermosyphon is closed with a brass plug, while the top end opens into a securely mounted large reservoir which is totally enclosed to prevent egress of the fluid when the tube is tilted. A probe thermocouple, held in a small bore copper tube, passes through the lid and can be adjusted to measure temperature anywhere along the tube axis. The bulk of convective fluid is maintained at a low temperature by circulating cold water through a cooling coil in the reservoir.

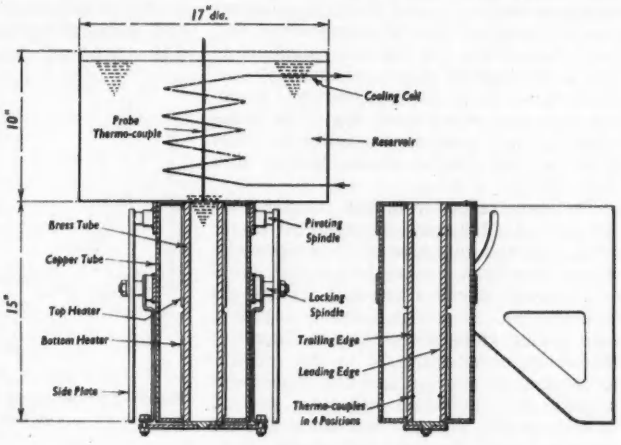

Fig. 1—General arrangement of thermosyphon apparatus

The assembly is arranged to be free to tilt in a vertical plane between stout side-plates rigidly fixed to the laboratory wall. Round the copper tube is a steel ring having two attached spindles, which fit into ball-races housed in the side-plates. The tube is retained in a tilted position by another ring having threaded spindles, which pass through slots machined in the side plates. Nuts on the spindles are tightened against the side plates. The inclination (between 0 and 45 deg. to the vertical) is measured by a pointer attached to one of the bearing spindles which moves over a protractor fastened to a side plate. Each heater section is connected in series with a rheostat and supplied from the 250V a.c. mains through a 5kVA "Variac" transformer, the power to each heater being measured by wattmeter. All thermocouples are connected to a potentiometer and the induced voltages measured by a null method, using a "Flik" mirror galvanometer in conjunction with an accumulator, a standard cell, and a lamp and scale.

An initial calibration test was carried out with the tube cavity charged with granulated cork (instead of fluid) so as to estimate the external heat loss, but the procedure for all vertical tests was basically the same. This consisted of first applying a potential difference from the transformer across the heaters. Adjustments were then made to the rheostats so that when steady conditions obtained, the temperature of the tube wall was uniform along its length. The heat loss was related to the temperature difference between the tube wall and the outer tube and the correlation used in subsequent tests when determining the net heat input to the fluid. The temperature of the brass tube was limited to about 260 deg. Fah. to guard against local overheating and melting of the soldered connections.

The procedure was slightly modified when the tube was tilted because of the temperature variation round the tube. Two sets of results were obtained for each angle, one for the condition when the tube temperature was uniform along the trailing edge, the other for when it was uniform along the leading edge. The derived results were based on heat transfer to the fluid in unit time Q being promoted by the temperature difference ΔT between the entering fluid (recorded by the probe) and the leading or trailing edge of the tube wall, unless the tube was vertical, in which case only one set of results was obtained. Tests were conducted on each fluid for the following angles of inclination:—

Angle deg.	min.	Tangent	Angle deg.	min.	Tangent
0	0	0	21	48	0·4
5	42	0·1	35	0	0·7
11	18	0·2	45	0	1·0

Reduction of Test Results

It may be shown by dimensional analysis that the variables likely to exert appreciable

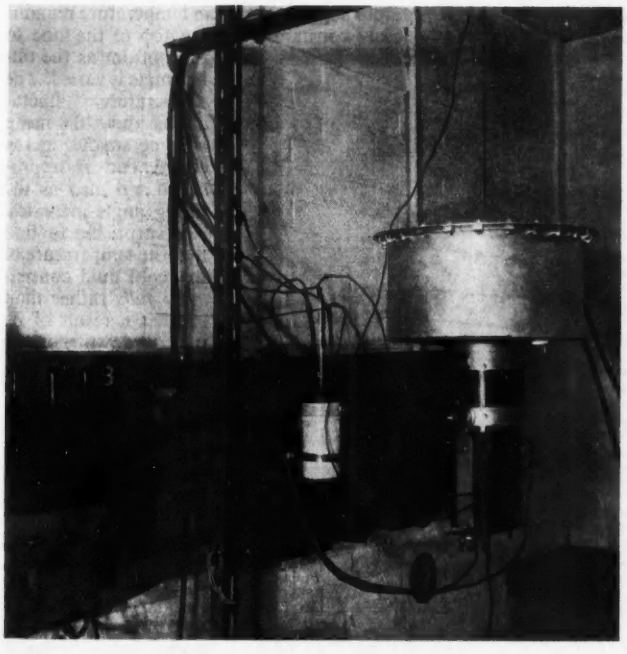

Fig. 2 (*a*)—Thermosyphon in vertical position

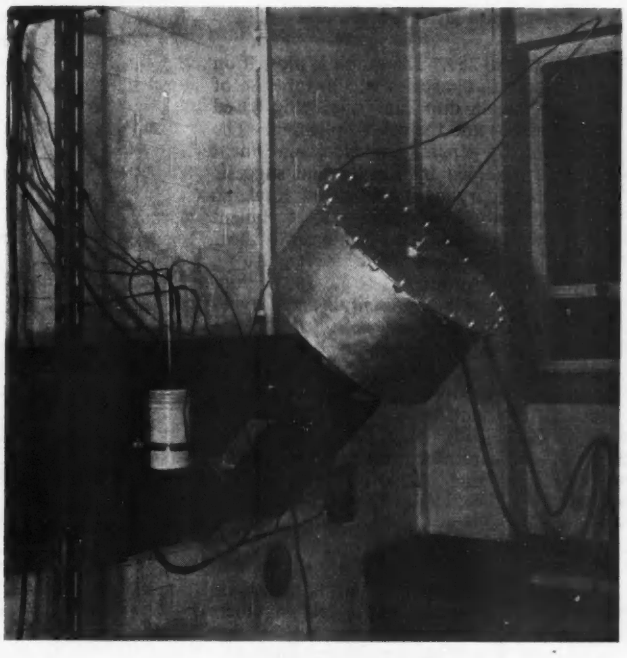

Fig. 2 (*b*)—Thermosyphon in inclined position

influence on the vertical static system may be grouped into four dimensionless parameters. These are :

l/r=length-radius ratio of tube.
$Pr=\nu/\kappa$ Prandtl number.
$Gr=\alpha g r^3 \Delta T/\nu^2$ Grashof number.
$Nu=Q/2\pi lk\Delta T$ Nusselt number

where l is the length of tube and r its radius, g being the external acceleration, in this case due to gravity. The remaining terms are fluid property values ; α is the coefficient of cubical expansion, k its thermal conductivity, while ν and κ are the kinematic viscosity and thermal diffusivity respectively. In the work to be described, the geometrical parameter l/r is constant. The Grashof and Nusselt numbers may be based on tube radius, as indicated above, or on tube length, when l replaces r in the above expressions. Extensive use is made of the Rayleigh number Ra (the product of the Grashof and Prandtl numbers), which is often more appropriate to free convection than the Grashof number. Subscripts r and l are used to specify the characteristic length on which the parameters are based, the fluid property values being evaluated throughout at the tube wall temperature.

When the tube is tilted a second geometrical parameter is added to the dimensionless groups, namely, the inclination θ of the tube. Tilting also modifies the external acceleration in the Grashof number to $g \cos\theta$, the Coriolis acceleration being simulated by the component $g \sin\theta$ at right-angles to the tube axis.

Experimental Results and Discussion

Ethylene Glycol Tests.—Fig. 3 shows the relationship between the Nusselt and Rayleigh numbers for ethylene glycol with the tube vertical. The Prandtl number range lies

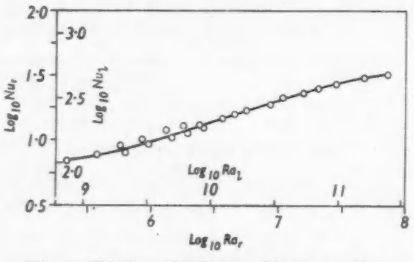

Fig. 3—Ethylene glycol test with tube vertical

between 15 and 250. The graph is plotted on double logarithmic scales which, for ease of reference, are in duplicate, one being based on tube radius and the other on length. The relationship is generally in close agreement with that obtained by Martin and suggests laminar boundary-layer flow at low Rayleigh numbers, with a transition to turbulent boundary-layer flow and increased heat transfer, when Ra_r reaches $10^{5\cdot9}$ ($Ra_l=10^{9\cdot4}$), and the Prandtl number is about 180. Both these flow regimes represent ordered types of flow ; it is, however, believed that the turbulent boundary layer regime is potentially unstable because of the tendency for the still-laminar cool fluid entering the tube also to become turbulent. When this occurs (at about $Ra_r=10^{6\cdot8}$), the heat transfer is diminished near the closed end because the flow reaching that part of the tube is progressively reduced with increasing Rayleigh number by mixing of the two turbulent streams at the open end. These are the characteristics of the relatively disordered fully-mixed flow. The small reduction in overall heat transfer at high Rayleigh numbers evident in Fig. 3 does, however, suggest that fully-mixed flow is not yet well established.

Fig. 4 is a cross-plot obtained from Fig. 3 and similar graphs for ethylene glycol with the tube at different angles of inclination. It shows the variation of heat transfer with tilting angle for a series of values of Rayleigh number, based on both leading and trailing edge temperature conditions. The heat transfer is clearly always less on the leading edge than on the trailing edge, as would be expected, and the difference increases with Rayleigh number. For all values of this parameter the heat transfer initially falls with increasing tilting angle, but subsequently improves and for low Rayleigh numbers may eventually exceed the value for $\theta=0$ deg. For $Ra_r=10^{7\cdot75}$, the initial reduction in Nu_r at the leading edge is as much as one-third (from 31 to 21) and recovery is not complete even when $\theta=45$ deg. The tilting angle for minimum heat transfer increases with Ra_r, and reaches about 20 deg. when $Ra_r=10^{7\cdot75}$.

The initial reduction in heat transfer when the tube is tilted may be attributed to the breakaway and migration of discrete particles of cool fluid from the periphery of the central core through layers of hot fluid towards the trailing edge. Since this probably occurs to some extent along the entire tube length it must bring about increased mixing and disturbance of the more ordered flow which, with ethylene glycol, would otherwise prevail. In other words, tilting at first accelerates the incipient tend towards fully-mixed flow, though the extent of the additional mixing, both radially and axially, will no doubt be determined by Pr, Ra_r and θ, as Fig. 4 suggests. What is certain is that any mixing near the open end, whether it is natural or created by tilting, means that, below the mixing zone, the flow velocities, rate of circulation and heat transfer, both local and overall, will be appreciably curtailed.

It is likely that an increase in θ beyond a certain value (determined apparently by Ra_r) causes the displacement of the core fluid as a whole rather than the movement of discrete particles. This bodily displacement probably involves less mixing and brings the cool core into closer proximity with the heated trailing edge surface as the fluid moves down the tube. The increased temperature difference between the tube wall and the adjacent fluid can only improve the heat transfer, and explains the increase which follows the initial reduction in Fig. 4. If the tilting angle is sufficiently great, the tendency to separation of the hot and cold streams may well spread to the region of the orifice and the reservoir immediately above. This must inevitably further reduce the natural mixing and delay the development of fully-mixed flow. The water tests described below lend credence to this interpretation.

At $Ra_r=10^{7\cdot75}$ the temperature difference between leading and trailing edges near the orifice increases from zero when $\theta=0$ deg. to 9 deg. Fah. at $\theta=11$ deg. 18 min. and to about 14 deg. Fah. when $\theta=45$ deg. There is a much smaller range of difference at the closed end, from zero when $\theta=0$ deg. to 4·5 deg. Fah. when $\theta=45$ deg. For the same Rayleigh

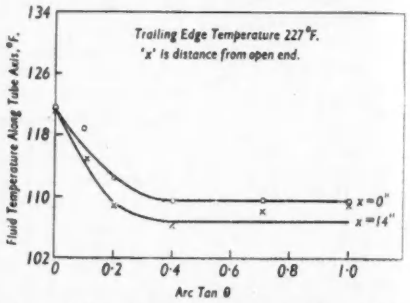

Fig. 5—Ethylene glycol tests showing effect of tilting on fluid temperature

number, the fluctuation of fluid inlet temperature about a mean changes markedly from 20 deg. Fah. when $\theta=0$ deg. to 1 deg. Fah. when $\theta=22$ deg. and to zero when $\theta=45$ deg. For constant values of $Ra_r>10^{6\cdot0}$ an increase in θ up to 20 deg. causes the heat distribution along the tube length to increase in favour of the upper half, but beyond this angle the distribution remains constant. This tendency for the lower half to become less effective in transferring heat supports the above interpretation of the initial effect of tilting the tube.

Explorations were made of temperature variation along the tube axis with the probe thermocouple for two values of average tube wall temperature, namely 111 deg. Fah. and 227 deg. Fah. Fig. 5 shows fluid temperature variation against tilting angle for the open end and a point near the closed end when the wall temperature is 227 deg. Fah. As the graphs suggest, the mean temperature remains nearly constant from the top of the tube to the bottom as the tilting angle is varied. The temperature fluctuations about the mean become smaller as the closed end is approached and also as the tilting angle increases. It is surprising to find that the temperature of the cool fluid consistently *falls* rather than rises as a result of its passage down the tube when the latter is tilted, though the maximum reduction is only about 2 deg. Fah. For a given tube wall temperature, an increase in θ initially causes a reduction in temperature of the cool fluid at all points along the axis, but Fig. 5 suggests that for larger values of θ the temperature at each point remains constant.

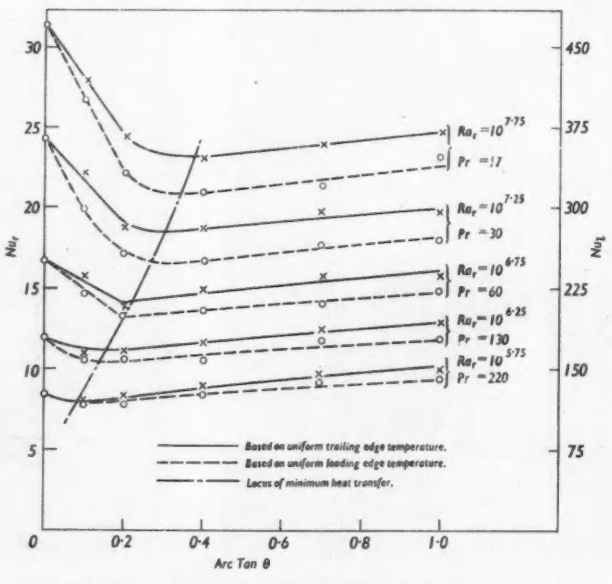

Fig. 4—Ethylene glycol tests showing effect of tilting on heat transfer

Water Tests.—The relation between the Nusselt and Rayleigh Numbers for water with the tube vertical is displayed in Fig. 6, and covers a range of Pr between 10 and 2. Heat transfer is less than for ethylene glycol over the whole range of Rayleigh numbers ; it is also inferior to that of laminar boundary-layer flow. This suggests that fully-mixed flow is the predominant regime throughout the test, a view which is strengthened by the relatively small Prandtl numbers.

The cross-plot of Nu_r against θ shown in Fig. 7 for water, and obtained in exactly the same way as Fig. 4, reveals that the heat transfer is again less along the leading edge. For given values of θ and Ra_r the difference

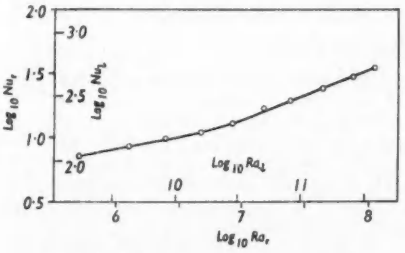

Fig. 6—Water test with tube vertical

in Nu_r for the two edges is, however, generally more marked than with ethylene glycol. But the most significant difference between the two sets of curves lies in the fact that with water Nu_r increases over the whole range of θ though the rate of increase diminishes with increasing θ. This flattening-off is more marked at high values of Ra_r, and for the leading edge the heat transfer may be said to remain almost constant when θ>17 deg. For $Ra_r=10^{7\cdot75}$ ($Ra_t=10^{11\cdot28}$) there is a gain in Nu_r of about one-third at the leading edge and two-thirds at the trailing edge, using the vertical test as a standard of comparison. This implies an overall average gain of about 50 per cent. Comparison of Figs. 4 and 7 also shows that, except for angles less than about 11 deg. at $Ra_r=10^{5\cdot75}$ and falling to approximately 4 deg. when $Ra_r=10^{7\cdot75}$, better heat transfer is obtained with water than with ethylene glycol for given θ and Ra_r. This is completely contrary to previous experience in vertical tubes ; Martin's work shows that for fully-mixed flow, the smaller the Prandtl number, the lower the heat transfer, for the same value of Ra_r.

It has been previously shown that in vertical tubes there is a good deal more natural mixing with water than with ethylene glycol. With water it is, therefore, unlikely that tilting the tube will significantly increase the degree of mixing by inducing the migration of particles of cool fluid, as appears to occur with ethylene glycol. It is much more likely that the lower viscosity of water permits an early and almost complete displacement of the cool core towards the trailing edge, the extent of this displacement depending on tilting angle, but always improving the heat transfer. For a given angle, the displacement appears to be in some inverse relation with the Prandtl number. As with ethylene glycol, the bodily movement of the core along the whole tube length tends to separate the hot and cold streams and thereby prevents their mixing. The interpretation may be summarised by saying that tilting a tube containing a fairly viscous fluid has initially the same effect as reducing its Prandtl number. The principal tendency of simulated Coriolis forces is, however, to separate the fluid streams, reduce mixing and increase the heat transfer.

The temperature difference between the leading and trailing edges with water reaches a maximum value of 14 deg. Fah. at the highest Rayleigh numbers when θ=45 deg. This is about the same as with ethylene glycol, but the wall temperatures in the present case fluctuate through a range of 5 deg. Fah. The fluid inlet temperature also fluctuates ; the range is about 16 deg. Fah. when θ=0 deg., falling to 10 deg. Fah. when θ=45 deg. Fig. 8 portrays the effect of tilting angle on fluid temperature at the top, bottom and midway along the tube axis for a trailing edge temperature of 180 deg. Fah.

Probe explorations were also carried out at trailing edge temperatures of 80 deg. Fah. and 130 deg. Fah. These show that for all tilting angles, the fluid temperature measured along the tube axis increases with distance from the open end, but the change becomes much less with increasing inclination. Fig. 8 shows that the temperature change between the two ends is reduced from 42 deg. Fah. when θ=0 deg. to 9·5 deg. Fah. at an inclination of 45 deg. The change of 42 deg. Fah. may be compared with that of 30 deg. Fah. obtained by Eckert and Diaguila (1952) with air at pressures from 64 lb to 125 lb per square inch absolute in a vertical tube of length 13·5ft and radius 1ft at a wall temperature of 214 deg. Fah. In the present probe tests the fluid inlet temperature remains constant no matter what the tilting angle may be. The fluctuations of fluid temperature tend to diminish as the probe is moved towards the closed end. The probe tests clearly confirm that the result of inclining the tube is to permit cool fluid to penetrate more readily to the bottom of the tube, further evidence being provided by the increased heat transfer in this region. All the indications are, therefore, that with water, or other fluids of similar Pr, inclination of the tube has a beneficial effect on both local and overall heat transfer.

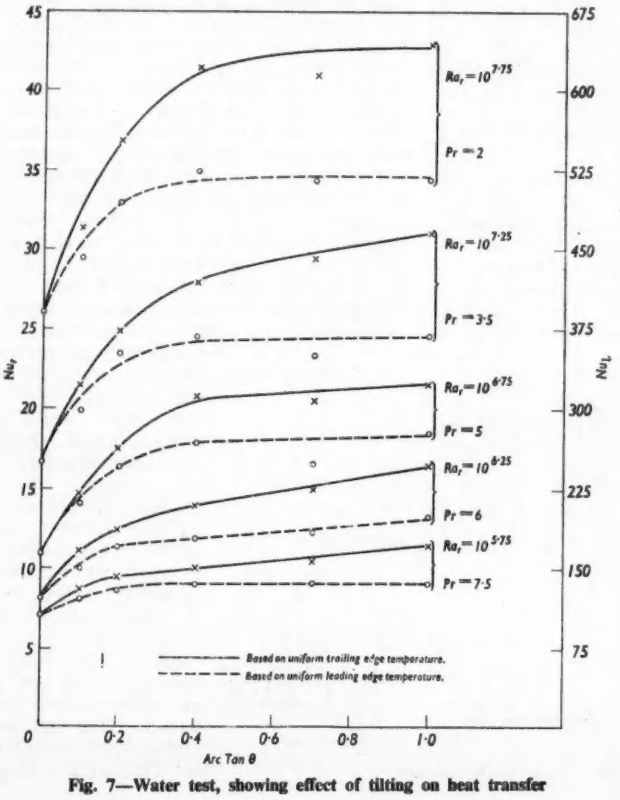

Fig. 7—Water test, showing effect of tilting on heat transfer

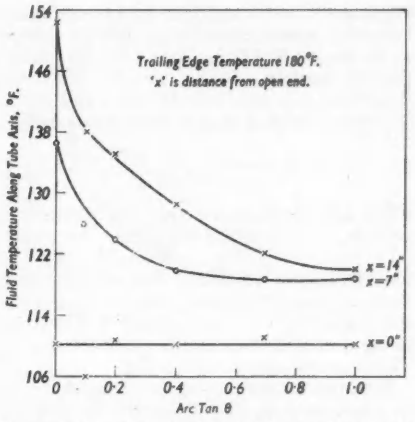

Fig. 8—Water tests, showing effect of tilting on fluid temperature

Earlier investigations of the effect of inclination by Elenbaas (1942), and Koch (1927), have been generally confined to plane surfaces, or open tubes at an inclination of 45 deg. Over a wide range of θ no appreciable change in heat transfer has been observed, and it has been generally assumed that this would hold good also for the thermosyphon. The present tests show that this is not so, for the very good reasons that with inclined plane or open surfaces (*a*) it is not possible for a moving stream of cool fluid to displace the rising layer of hot fluid, and (*b*) fully-mixed flow does not occur.

The Magnitude and Effect of Coriolis Forces

The Coriolis acceleration of a fluid particle in a rotating turbine blade is given by $2u\omega$, where u is the particle velocity relative to the passage and ω is the angular velocity of the blade, i.e. of the turbine rotor. The problem of determining the Coriolis acceleration thus resolves itself into evaluating u. At the present time insufficient is known either of turbulent boundary-layer flow in the thermosyphon or of the fully-mixed turbulent regime to be able to estimate u with anything like certainty, for the Prandtl numbers contemplated, and particularly at the Rayleigh numbers appropriate to turbine operating conditions. A further complication in estimating u is the implicit nature of the problem, in that the Coriolis acceleration modifies the flow pattern and heat transfer, which in turn modifies u and thus the Coriolis acceleration, and so on.

Eckert and Jackson (1950) have, however, obtained solutions of the boundary-layer equations for turbulent boundary-layer flow using assumed velocity and temperature profiles. These yield the following equation for maximum Reynolds number :—

$$Re_{max}=0\cdot355Ra^{0\cdot5}\,.\,Pr^{-0\cdot589} \quad . \quad . \quad (1)$$

In a rotating passage the maximum buoyancy acceleration associated with centrifugal force is represented approximately by $\omega^2R\alpha\Delta T$, where R is the average radius of rotation to the mid-section of the blade. The ratio of

maximum Coriolis acceleration to maximum buoyancy acceleration β may then be shown to be $2u_{max}/\omega R\alpha\Delta T$, u_{max} being the maximum particle velocity. Eckert and Jackson substitute for u_{max} and ω from Re_{max} and Ra in (1) above and find that at mean blade radius

$$\beta = 0{\cdot}71 Pr^{-0{\cdot}089}\left\{\frac{L}{2R\alpha\Delta T}\right\}^{0{\cdot}5} \quad . \quad . \quad (2)$$

where L is the blade length. For a free-convection, liquid-cooled turbine, in which $\Delta T = 315$ deg. Fah., $Pr = 1{\cdot}74$, $R = 2L$, $\alpha = 0{\cdot}00043$ per deg. Fah., they estimate that $\beta = 0{\cdot}84$, and it is then a simple matter to show that the ratio of Coriolis acceleration to the centrifugal acceleration is about 0·114. This corresponds to $\theta = 6{\cdot}5$ deg.

It would be unwise to accept these estimates as corresponding at all closely to reality, because the above reasoning is, at best, only a first approximation, but it is probably safe to infer that actual Coriolis forces have a significant influence for the better on heat transfer rates. This inference is based on the reasonable assumption that the coolant in a blade passage would have a Prandtl number near unity and would therefore behave more like water then ethylene glycol. It is also reasonable to suppose that the tests described cover any value of θ which could conceivably occur in a blade passage ; θ would, in fact, vary from zero at the closed end (where u is zero), possibly reaching a maximum near mid-section, with little further change if mixing were appreciable near the open end. But if mixing had been substantially reduced by Coriolis forces, θ would be greatest at the orifice.

Conclusions

This article presents the results of an experimental investigation into the effect of tube inclination on free convection in the open thermosyphon. The work has been carried out largely in an effort to discover what influence Coriolis forces are likely to have should the system be used to cool the rotor blades of high-temperature gas turbines. For this reason parameters have been chosen which cover as far as possible those expected to occur in blade coolant passages. The tests show that transverse accelerations should always be taken into account in evaluating the heat transfer ; for a moderately viscous fluid the heat transfer is initially reduced by tilting the tube, but subsequently recovers if the inclination is further increased. For a fluid whose Prandtl number approximates to unity (and this corresponds most closely with the practical application), the heat transfer always increases with tilting angle, though the rate of increase falls off practically to zero at the larger angles. The local heat transfer varies round the circumference of the passage from a maximum at the trailing edge to a minimum at the leading edge. There is clearly scope for extension of the work to include the effect of change in length-radius ratio and the coverage of a wider range of Prandtl numbers.

Acknowledgment

The authors are indebted to Professor A. F. Burstall, D.Sc., Ph.D., M.I.Mech.E., in whose department the work was carried out, for his invaluable encouragement during the course of the project, and for the provision of the necessary experimental facilities. They also acknowledge the advice tendered on a number of occasions by Dr. F. J. Bayley, M.Sc., A.M.I.Mech.E., which contributed materially to the advancement of the investigation.

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Modern Tendencies in Arch Dam Design

By SERGE LELIAVSKY, Ph.D., M.I.C.E., M.Am.Soc.C.E.

No. III—(*Concluded from page 892, December 20*)

It will be apparent to readers of this journal who have studied articles published from time to time, containing descriptions of arch dams in various countries, that many variations are possible. The author of this article points out that some of this variety results from differences of opinion amongst engineers, as to how the stresses in such dams should be calculated and as to how much reliance should be placed on model tests. He goes on to study whether any classification is possible and finally refers to certain aspects of dam design, such, for example, as spillways, the capacity or location of which may have an influence on the kind of dam adopted.

Hydraulic Design

IT will be observed that the foregoing discussion has centred chiefly on the structural aspect of the arch dam problem. It must be realised, however, that in regard to hydraulics also, recent Continental design methods have shown a tendency to break away from the century-old tradition.

The better to realise the difference between the old and new concepts belonging to the relevant hydraulic theories, attention will be called again to Fig. 20, showing an instance (the Cismon dam at Ponte della Serra, in Italy) in which an expensive central pier and two auxiliary arches were incorporated in the project, for the sole purpose of preventing the flood waters falling over the crest of a high arch dam. Now what was there in this relatively recent past that the designers could have been afraid of ? Two scarecrows appear to have been particularly responsible for causing unjustified apprehension and alarm : vague ideas about the alleged vibrations which the flowing water was supposed to set up in the structure of the dam, and erosion of the foundation, behind it, at the point where the falling sheet of water struck the rock.

The problem of the vibrations of civil works incorporated in hydraulic installations has been dealt with by the author elsewhere.[33] On the other hand, the question of tail erosion commands a particularly wide section of technical literature, which exceeds by far the scope of this article.[34] It will suffice to mention that, in the case under consideration, i.e. arch dam design, all uncertainties regarding these problems were laid aside by reduced scale hydraulic model tests, which yield specific and definite information on the subject. The point is of impce ; ortan for when the work is to be located in a narrow gorge (such as those which abound in the mountainous regions of Europe), the decision whether to use an arch dam or not depends frequently on the available possibilities for evacuating the flood discharge ; whilst, on the other hand, a cheap arch dam may often be a condition *sine qua non* for a commercially sound financial enterprise. Thus the whole project depends on the hydraulic solution adopted by the designer.

In an interesting paper[35] belonging to the symposium, frequently referred to in the foregoing pages, the prominent Portuguese engineer, Mr. A. C. Xerez, gives a number of examples illustrating the main principles of the foregoing argument. He distinguishes several characteristic cases and relevant design problems. First comes the case when the flood is not excessive, the dam is of low or medium height, and there is no power station located at its foot. Discharging the flood freely over all (or part of) the crest, controlled by flood gates or not, is then the best solution. Next, take the case when the arch dam belongs to the so-called "thick" type. Here advantage can be taken of the slope of the downstream face of the structure to guide the flow, although this will require the "nappe" to be forced to follow its shape. In this case, if the width of the valley allows, the power station may be built at the foot of the dam, side by side with the spillway escape channel. Both cases are representative of "medium" conditions. Consider now an extreme case ; or, to be more precise, examine the conditions occurring when the flow per unit length of crest is relatively high —say, 80 cubic metres per second, per metre, or more—whilst the dam is 100m high or higher. These are critical conditions, calling

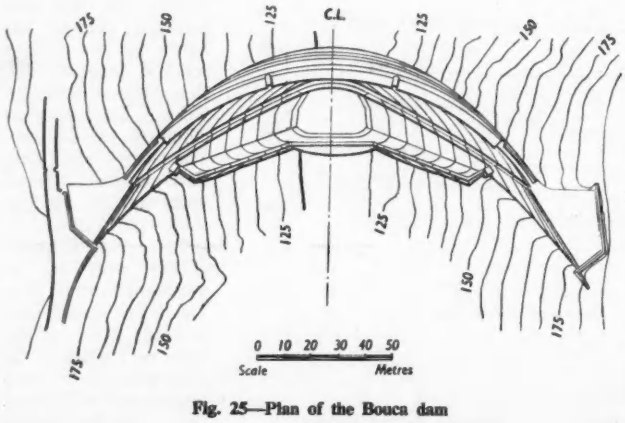


Fig. 25—Plan of the Bouca dam

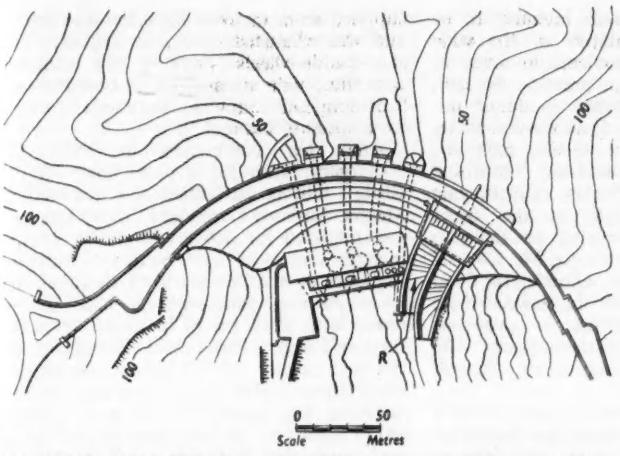


Fig. 26—Castelo do Bode dam : plan of the dam, power station and spillway

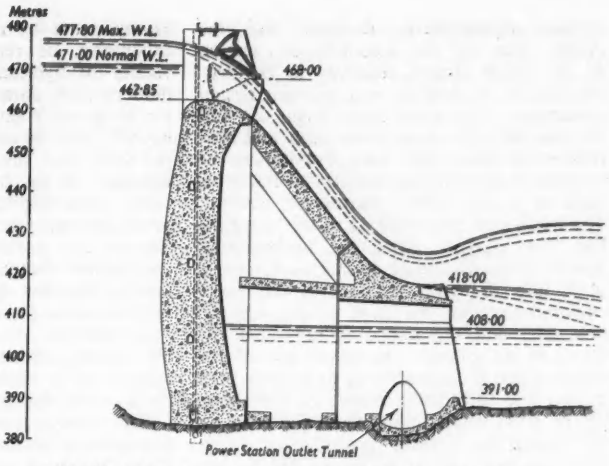


Fig. 30—Picote dam : central profile of the dam and spillway

for careful attention. From the point of view of cost, the most economical solution is still to allow the flood discharge to fall freely over the crest ; but in this extreme case the solution involving an independent spillway (or even a gravity dam at a wider spot of the same valley) must also be considered, for under such severe conditions they may possibly be more safe.

Analytical treatment is easier in the case of free discharge taking place over the entire length of the crest. Model tests on the other hand, though they are always necessary, play a particularly responsible and comprehensive role, in the case when a power station is located at the foot of the dam, and consequently, the flood discharge enters the spillway asymmetrically.

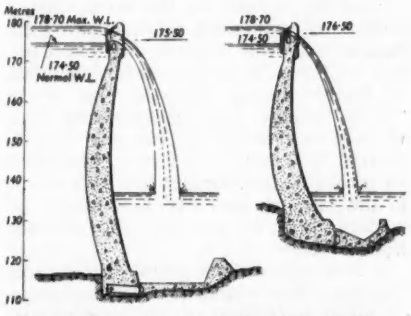


Fig. 27—Bouca dam : central and lateral profiles

The discussion of these general principles is further developed by application to specific instances selected from recent Portuguese works. The thin arch dam at Bouça (see Figs. 25 and 27) may serve to exemplify the hydraulic conditions herein classified as case one, viz. there was here plenty of space for placing the power station on the right bank of the river, some distance downstream of the dam, and there was therefore no objection against letting the flood discharge (2200 cubic metres per second) fall freely over almost the entire length of the crest of the dam, as shown in the figures. Under such conditions the hydraulic problems to be solved by model tests were chiefly concerned with the choice of profile of the sill, the piers and the levels and lengths of the three sections of the crest, i.e. the lower section in the middle and the higher lateral sections on either side of it. Particular attention is devoted in such experiments to the elimination of the vibratory effects, which may be set up at the earlier stages of the flood, when the nappe is still very thin.

Another Portuguese arch dam, the Castelo do Bode, is chosen by the same author as an illustration for the hydraulic problem belonging to case two. As seen from Figs. 26 and 28, the power station occupies, in this case, much of the space available at the foot of the dam and there is, therefore, no other way for evacuating the discharge except by diverting the flow into a side channel (or overfall spillway) located on the left side of the structure. The design of this spillway, in so far as hydraulics is concerned, is almost entirely a matter of model tests. The nappe must be forced to follow the alignment of the downstream face of the dam, which calls for a particular design of the intake structure and is generally possible only within a certain range of slopes. Another problem belonging to the scope of experimental study is that of delivering the spill water into the downstream channel of the river in such manner as to permit aeration, and thus, avoid erosion. In the case of the Castelo do Bode dam (see *R* in Fig. 26) this double objective was achieved by gradually reducing the width of the spillway channel —a result derived entirely from model tests.

We have mentioned earlier that, however far hydraulic knowledge has proceeded and whatever facilities may be afforded by the use of modern materials, there are, nevertheless, conditions under which it is advisable to adopt the more expensive solution of building a separate tunnel for evacuating the flood. This is the case of the Cabril dam, shown in Fig. 31. In this case the height of the dam is 135m and the flood discharge is 2000 cubic metres per second. The case comes, therefore, under the critical condition quoted above under heading three. It must be realised, however, that the decision to build separate tunnels was adopted in this case only after extensive model tests showed that other solutions might not be altogether safe.

Finally, a rather

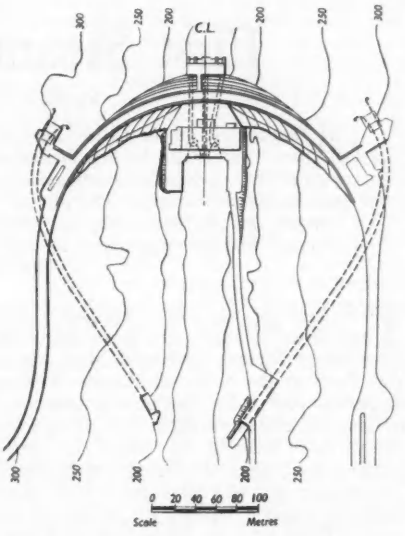


Fig. 31—Cabril : plan of the dam and spillway

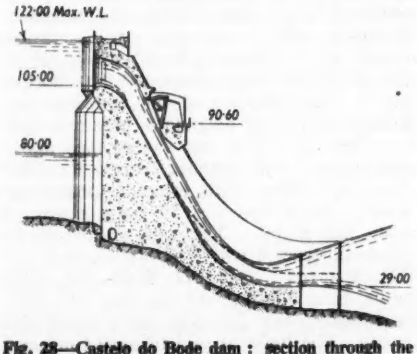


Fig. 28—Castelo do Bode dam : section through the spillway channel (see *R* in Fig. 26)

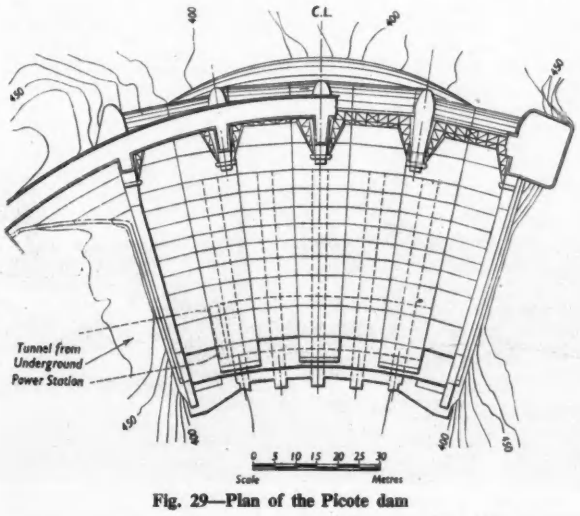


Fig. 29—Plan of the Picote dam

original arrangement, designed for the Picote dam on the international section of the River Douro, deserves to be mentioned, for it exhibits rather daring design tendencies. As seen from Figs. 29 and 30, the dam is about 90m high and only little more than 100m long, but it must be capable of discharging exceptional floods as high as 11,000 cubic metres per second. The main idea incorporated in this design is that the outflow from the underground power station depending on this work, returns back into the river channel in the space enclosed between the dam proper, on the one side, and the nappe falling from the crest, on the other. The advantage of this arrangement is claimed to be as follows : the impact and turbulence created by the shock of the flood water falling from the crest on the bed of the channel (protected or otherwise) are said not to be augmented by the dynamic effect of the water returning from the turbines, as would have been the case had the more usual scheme been adopted. That, of course, is a point for model tests to verify.

It must be realised that the foregoing few examples are by no means intended to be exhaustive, or representative of the wide variety of hydraulic problems involved in modern arch dam design practice. In fact, the scope of such problems is almost unlimited. On the one hand, we must consider the small but important details, such, for instance, as the much-discussed " Morning Glory" type of inlet for by-pass tunnels, gate arrangements, &c. ; whilst at the other extreme are problems bearing on the general layout of capital works, e.g. Mr. Coynes' famous ski-jump spillway, allowing the flood to pass above the station. In between these two extremes, are numbers of problems of various moment and significance. The subject as a whole is obviously beyond the scope of this article.

In conclusion, the author wishes to reiterate his indebtedness to the American Society of Civil Engineers, whose symposium on the subject of arch dams will repay study, whatever the nationality of the student. He wishes also to tender his sincere gratitude to all the authors who participated in this symposium and whose names are mentioned in the foregoing pages.

First Steamer to France

By H. PHILIP SPRATT

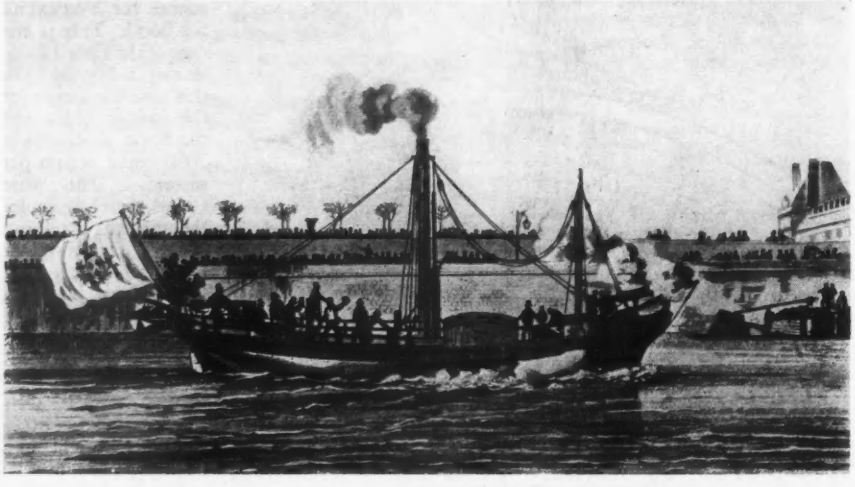
At Dumbarton, on the Clyde, soon after Henry Bell had introduced his famous " Comet " of 1812, *the first steamboat for public service in Europe, there was built in* 1813–14 *another small paddle steamer destined to acquire a double distinction in maritime history: she was to be the first " steam packet " on the River Thames, and the first to cross the Channel to France. Her history is here related together with some reference to other early steamers on the Seine and in the Mediterranean.*

THE keel for the P.S. " Margery " was laid down in 1813 ; the vessel was built of wood by Messrs. Archibald MacLachlan and Co.,[1] to the order of Messrs. William Anderson and John McCubbin, merchants of Glasgow, and launched in June, 1814, from the yards at Dumbarton, which were later acquired by Messrs. W. Denny and Brothers. The wooden hull was carvel built, with round bluff bows and a tapered run-in toward the stern. There was one flush deck, with pronounced sheer. The vessel carried a female bust head and bowsprit above her curved raked stem, and had a square stern which protruded behind the raked sternpost. The rudder was steered with a simple hand tiller. The tall slender funnel, about 21in diameter, was placed aft of the paddle boxes, and rose 30ft above the deck. It served also as mast, and a yard with square sail could be hoisted when the wind was favourable. There was also a small fore-mast, set well forward in the bows, but not so tall as the funnel. One small boat was carried over the stern. For her propulsion, the vessel was fitted by James Cook, of Tradeston, with machinery of 10 nominal h.p.[2] This comprised one vertical cylinder 22in diameter by 2ft stroke, which drove by means of two side levers on to the paddle crankshaft, and was said to have developed 14 actual h.p.[3] Steam at low pressure (about 2 lb per square inch) was supplied from an iron flat-sided flue boiler, and was exhausted into a condenser. The side paddle-wheels were 8·75ft diameter, each fitted with six radial float boards about 2·5ft long and 15in wide, and made 32 r.p.m. for a speed of 6 knots.

After her completion in 1814, the " Margery " ran for a short time on the Clyde ; but in November she was sold to Messrs. Anthony Cortis and Co., of London, and prepared for delivery.[4] As her overall breadth was 4·3ft more than the width of the locks on the Forth and Clyde canal, her sponsons and paddle-wheels had to be removed to allow her to be towed up to the Firth of Forth.[5] From there she sailed down the East Coast ; her tall funnel, like that of the " Comet " (1812), served as mast on this occasion. She entered the Thames in January, 1815, much to the astonishment of naval crews anchored in the estuary,[6] and of the London public. Under the command of Captain Anthony Cortis, this first " steam packet " on the River Thames started from London Docks on Monday, January 23.[7] She maintained a public service between London and Gravesend[8] on alternate days ; but Captain Cortis had to be replaced later, under the Watermen's Act, as he was not a licensed member. The " Margery " was laid up several times for repairs, and at the end of her first season she was withdrawn.[9]

About March, 1816, she was chartered or sold to Messrs. Andriel, Pajol et Cie., of Paris,[10] renamed by them the " Elise," and refitted for service on the River Seine.[11] Under the command of Captain Pierre Andriel, and with Captain Anthony Cortis and Mr. W. Jackson (a former collaborator of Robert Fulton) also on board,[12] the " Elise " steamed from the Thames in stormy weather to Newhaven. She left there on March 17, 1816, battled her way[13] across the Channel (the first steamer that ever did so) in the face of southerly head-winds, and reached Havre the next day, after seventeen hours at sea.[14]

It is worth mentioning here that the same Captain Pierre Andriel later introduced the first steamboat service in the Mediterranean,[15] with the " Ferdinando Primo." This vessel was built of wood at Naples by Messrs. Giuseppe Libetta and Adolfo Wolff, and launched on June 24, 1818, for the newly-formed Società Napoletana Pietro Andriel. Her dimensions were as follows :—Gross register, 247 tons ; net, 185 tons ; length between perpendiculars, 127·3ft ; breadth of hull, 20·2ft ; breadth over paddle boxes, 32ft ; depth in hold, 9·5ft ; draught, 6·4ft. The " Ferdinando Primo " is shown in her authentic representation[16] as a three-masted vessel, with the paddle-wheels placed well forward. She had sixteen private cabins and a public saloon for fifty persons forward. Her side lever machinery, of 32 nominal h.p., occupied 27ft of the hull amidships. It was of British construction, believed to have been obtained from James Cook, of Tradeston, Scotland, and comprised two vertical cylinders, 27in diameter by 3ft stroke, which are stated to have developed 50 effective h.p.[17] The cylinders of the condenser air pumps were 20in diameter. Steam at low pressure, about 2 lb per square inch above atmospheric, was supplied from a flat-sided iron flue boiler, with internal furnace 6ft wide ; the firebox was 5ft deep, measured over the ashpit. The side paddle-wheels were constructed with iron spokes and rims 12ft diameter ; each was fitted with eight radial float boards, 4ft long and 16in wide, and made about 22 r.p.m. for a speed of 6 knots. The boiler is said to have consumed 2 tons of coal per day.[18] The " Ferdinando Primo " sailed from Naples in October,



Arrival at Paris, on March 29, 1816, of the steamer " Elise " from London, Captain Andriel

1818, under the command of Captain Andrea di Martino,[19] and with a British mechanic on board. Her arrival at Genoa, and her manœuvres at that port attracted much popular interest.[20] She left Genoa on October 30, with ten passengers, and arrived at Marseilles on November 3,[21] the first steam vessel ever seen in that port.[22]

Turning back to the history of the " Elise," she remained at Havre until March 20, then continued up the Seine to Rouen and Paris, where she arrived on March 29, 1816, in front of the Tuileries, amid scenes of much enthusiasm, as shown in our illustration.[23] She later redescended the Seine, and started a public service between Rouen and Elbeuf.[24]

Meanwhile, in April, the veteran steamboat pioneer Marquis Claude de Jouffroy d'Abbans (1751–1832) had obtained a French patent[25] and had installed himself at Petit-Bercy,[26] near Paris, in partnership with his son Achille F. E. de Jouffroy. As was pointed out at the time,[27] Jouffroy had the indisputable priority of invention over Andriel, and even over Robert Fulton.[28] Some efforts were made for a rapprochement of the Société Jouffroy d'Abbans and Messrs. Andriel, Pajol et Cie., but in vain ; the rival companies entered into competition.[29]

The Jouffroy steamboat " Charles-Philippe " was launched at Petit-Bercy on August 20, 1816, by the Comte C. P. d'Artois, with much ceremony and popular enthusiasm,[30] for service on the River Seine. Her dimensions were as follows :—Burden, about 150 tons ; length overall, 149ft ; length between perpendiculars, 136ft ; breadth of hull, 14·9ft ; breadth over paddle boxes, about 30·8ft ; depth, 7·5ft ; draught, 3·2ft. The wooden hull was constructed with a flat bottom, rounded to the side walls. The vessel was sharp in the bow, and her narrow beam was maintained almost parallel aft of the paddle-wheels, with a short run-in of about 12ft at the stern. She carried a dragon head at the bow, and a female bust at the stern. There was a raised promenade deck down the middle of the vessel, which provided additional depth and window space for the saloon below. The paddle-wheels were encased in ornamental side boxes. There was no deck house ; the rudder was fitted with a simple hand tiller. The tapered funnel with bulbous top, placed well forward of the paddle-wheels, rose about 15ft above the promenade deck. There was no mast, and no evidence that a sail was ever used. Steam was relied upon as the sole means of propulsion.

The " Charles-Philippe " was fitted with a horizontal steam cylinder about 27·2in diameter by 77in stroke (rated at 20 nominal h.p.), which could have developed about 32 effective h.p. The piston-rod was attached to a double toothed rack, with ratchet mechanism,[31] similar to that used in the River Saône experiments of 1783, which, on each inward and outward stroke, produced a continuous rotative movement of the toothed wheel mounted on the paddle shaft. Steam at about 2 lb per square inch pressure above atmospheric was supplied from an iron boiler, which was coated on the outside with clay insulation. The paddle-wheels were 10·7ft diameter, fitted with radial float boards, 6·4ft long and 2·1ft wide, and made about 25 r.p.m.

The " Charles-Philippe " ran her first trial on November 20, 1816, after which certain alterations were made to the machinery. Later, on Tuesday, December 3, she mounted the Seine from the Port de la Râpée to Charenton,[32] a distance of about 3 miles, in one hour. The river current at the time was estimated at 3·7 m.p.h., so that the effective water speed of the vessel amounted to 6·7 m.p.h. The ratchet mechanism proved defective, however, as it had done in the previous experiments. Unfortunately, the " Charles-Philippe " never became a commercial success.

Neither did the " Elise " prove any more successful in her service on the Seine. British records of this vessel were closed in October, 1816 ; but her timbers are said to have lain as late as 1888 on the banks of the Seine.[33] She was the first steamer that ever plied in both British and French waters. Principal dimensions of the " Elise " were as follows :—Burden, 38 tons ; length overall, about 73ft ; length on deck, 63ft ; length on water-line, 59ft ; length of keel, 50·5ft ; breadth of hull, 12ft ; breadth over paddle boxes, 19·5ft ; depth in cabin, 6·3ft ; depth in hold, 5·5ft ; draught, 4ft.

In conclusion of these notes, the writer wishes to record his indebtedness and sincere thanks for the invaluable help received from Mr. C. E. C. Townsend, Port of London Authority ; from the municipal libraries and archives at Lyons, Besançon, Marseilles and Naples ; from the Archivio di Stato di Napoli, and the Museo Nazionale di San Martino, Naples ; the Museo Storico della Marina, La Spezia, and from the Musée de la Marine, and the Bibliothèque Nationale, Paris.

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Electrogyro Shunting Locomotive

SOME notes have been received from the National Coal Board of a trial surface shunting locomotive which has been built by Sentinel (Shrewsbury), Ltd., in conjunction with the Swiss firm of Oerlikon. In this electrogyro design of locomotive energy is stored in two flywheels combined with squirrel-cage induction motors, which work first as motors taking power from a three-phase supply and converting it into kinetic energy, which is stored in the flywheels. To move locomotive the stored energy is reconverted into electrical form and supplied to two traction motors which drive the locomotive. The gyros work normally from just under 3000 r.p.m. to about 1800 r.p.m.; to speed them up takes two and a half minutes and the shunting locomotive can then work for up to about thirty minutes on this charging depending on the duty.

The locomotive has an 0–4–0 wheel arrangement and weighs just under 40 tons in working order. Its electrogyros have a rated voltage of 500V and are designed for a charging frequency of 50 c/s, the working frequency being 49–30 c/s. They are fitted to 63¾in diameter flywheels each weighing 1·48 tons, and the stored energy at the maximum speed of about 3000 r.p.m. is 9kWh each set. The two squirrel-cage induction traction motors fitted to the locomotive drive through reduction gearing and have a continuous rating of 25kW at 550V.

For the present trials, three charging stations have been set up—one in the locomotive shed and two on the line, about a mile apart. When the locomotive stops at a charging mast, a collector pole is swung out by pneumatic gear to connect the locomotive with four bare contact rails which are not alive until a pilot circuit through the locomotive closes a contactor in the charging station. The gyros are then run up to near synchronous speed, at which 18kWh of energy are stored, of which about 12kWh are available for use—the remainder represents the energy stored at the minimum working speed of the gyros. When the charging mast is swung back, the locomotive can move.

The electrical principle underlying operation of the locomotive is that a three-phase induction motor will generate alternating current when driven externally and excited by condensers, and two banks of condensers are housed in the front compartment of the locomotive. The driver operates a handwheel to regulate the value of capacity connected, which, together with the load on the traction motor (weight of train, gradient, locomotive speed) and the gyro speed, determines the voltage generated by the gyros. There is an automatic voltage-limiting device with compensation for heavy starting currents.

A second manually operated controller changes the connections of the traction motor windings and gives the locomotive four forward and four reverse speeds. This is achieved by altering the number of poles. As the gyros slow down, frequency and generated voltage fall and reduce the locomotive speed.

The gyros run in an atmosphere of hydrogen at reduced pressure, and it takes about eleven hours for them to come to rest from maximum speed ; if they ran in air at normal atmospheric pressure they would stop in about four hours. The use of hydrogen cooling also reduces the loss of revolutions at signal stops and traffic hold-ups. It is stated that with the locomotive standing the gyros take over one and a half hours to slow down from their maximum speed to 1800 r.p.m., and it takes considerably longer for the speed to fall to a value at which the locomotive is immobile.

The number and position of the charging stations for a locomotive of this type are based on a careful assessment of its duties ; the two and a half minutes required by a charge are not necessarily detrimental as traffic conditions make stops inevitable. Where it is desirable to have the locomotive instantly ready for duty at the beginning of a shift, the gyros need never be allowed to run down and a reduced charge in the shed can maintain their speed as required. It is stated that if the system and equipment prove successful and economic the use of a similar fireproof locomotive for underground service will be considered.

Metallurgical Topics

American Society for Metals

PAPERS presented at the thirty-ninth Annual Convention of the American Society for Metals in November, 1957, covered a wide range of subjects. In the following short account brief indications are given of the contents of some of them.

CARBON AND LOW-ALLOY STEELS

Evidence was offered of the correctness of predictions, based on the dislocation theory, of the upper yield stress of low-carbon steels as a function of temperature and rate of application of stress (27).* In annealed mild steel tested at room temperature, small non-elastic strains occur before extensive yielding takes place with the formation of Lüder's lines. At sub-zero temperatures the yield point is less well defined and is difficult to determine from the usual load-extension data. The sequence of events leading to gross yielding at −196 deg. Cent. has been explored and it was found that transition from the microstrain to that at which Lüder's lines are evident is not abrupt, as at room temperature, but occurs by a slowly accelerating creep process which, at certain stress levels, can occupy an appreciable time (9). In the quench-ageing of mild steel, carbon and nitrogen are retained in supersaturated solid solution and are subsequently rejected from the solution in the form of carbides or nitrides. The stages of ageing, studied by means of optical and electron microscopy and electron diffraction, were found to be: for ferrite supersaturated with carbon→ε-carbide→cementite; with nitrogen→α''-$Fe_{16}N_2$→γ'-Fe_4N; and with carbon and nitrogen—ε-carbonitride→cementite (containing nitrogen). At relatively low ageing temperatures, only the first stage was observed whereas both stages occurred at intermediate temperatures. At relatively high temperatures, the final products apparently formed directly from the ferrite solid solution. Both form and size of the particles were studied at each stage. In the iron-carbon-nitrogen alloy the ε-phase was more stable than in the iron-carbon alloy and the presence of nitrogen in the cementite favoured the formation of relatively large plates (33).

Two papers (42, 50) refer to the effect of lead in free-cutting, high-sulphur steels. In the process of solidification lead becomes entrapped in the same interdendritic regions as manganese sulphide, and remains closely associated with it in the hot rolled steel. Rolling extends the sulphide inclusions into the familiar lenticular shape and the associated lead appears as sheaths or "tails" at each end of the elongated inclusion. Most, if not all, of the lead is present in the elemental form (50).

In a number of low-alloy steels of different hardenability, but all tempered to the same hardness (Rockwell C 36), it was found that a relationship exists between the amount of martensite obtained in the as-quenched condition and the endurance limit. The presence of a small percentage of non-martensitic structure in quenched steel had a deleterious effect on the fatigue strength of the tempered material. When the martensite was less than 85 per cent, however, the endurance limit was not so sensitive to microstructure. The endurance limits of the five steels tested were nearly the same for a given amount of martensite when tempered to a given hardness, irrespective of their hardenability (16).

A comparison was made of the results of torsion tests on a 1 per cent carbon, 1 per cent chromium steel in the austempered and the oil-hardened and tempered conditions. In the austempered steel a linear relation between torsional yield strength and hardness persisted to a higher hardness level than in the quenched and tempered steel. Ductile fracture also continued to a higher hardness and torsion test data showed less scatter. The erratic results in torsion tests on the quenched and tempered steel in a very hard condition (over Rockwell C 57) were attributed to percarbide (Fe_3C) films and elongated cementite particles, not present in the austempered steel (46).

STAINLESS STEELS

The "two-score" type of chromium steel with about 2 per cent of nickel provides the highest corrosion resistance among the ferritic steels combined with good mechanical properties in the heat-treated condition. The treatment which renders the austenitic 18 : 8 steel immune from intercrystalline corrosion has a very bad effect on the corrosion resistance of the plain 18 per cent chromium steel. To investigate the transition from one to the other the effect of nickel from 0 to 8 per cent on the intercrystalline corrosion of steels containing 18 per cent of chromium has been investigated by corrosion tests in boiling 65 per cent nitric acid and by metallographic examination. The rate of corrosion after water quenching from 1095 deg. Cent. was greatest in the 18 per cent chromium steel and fell to a low figure in 18 : 8. After slow cooling from 760 deg. Cent. it was low for the plain chromium steel, but increased with increasing nickel, slowly at first and then rapidly, to a high value for 18 : 8, though this temperature was sufficiently high almost to inhibit intercrystalline corrosion in the austenitic steel if water quenched. Furnace cooling from 1095 deg. Cent. of steels containing 2 to 3·5 per cent of nickel resulted in the maximum rate of attack. The limit for ferritic treatment was given as 2·5 per cent of nickel (51). Another paper dealt with some difficulties encountered in the heat-treatment of the two-score type of steel, which is only suitable for use in the high-strength condition. At lower strength levels the heat-treated steel frequently contains strings of ferrite which adversely affect transverse properties. On the other hand, there may be difficulty in obtaining the highest possible yield strength owing to the presence of retained austenite (18). Other papers dealt with strain hardening (10) and carbide precipitation (32) in chromium-nickel austenitic steels, and with phase relationships in austenitic chromium-manganese-carbon-nitrogen steels (29).

CHROMIUM AND CHROMIUM ALLOYS

As a result of determinations of the torsional properties of forged chromium, it was concluded that the metal showed substantial ductility above 250 deg. Cent. and began to lose strength only above 750 deg. Cent. Its transition temperature was about 50 deg. Cent. and was not affected by strain rate in the range 0·001in to 0·05in per inch per minute. Prestraining at 250 deg. Cent. produced a considerable increase in room temperature ductility and the transition temperature was depressed to below room temperature. Prestraining at higher temperatures, especially above 400 deg. Cent., was less effective and might even cause an increase in transition temperature. Recrystallisation at 900 deg. to 1000 deg. Cent. eliminates the effect with reversion of the transition to 50 deg. Cent. (48). The temperature dependence of tensile and stress-rupture properties of arc-melted, extruded and swaged chromium were investigated up to 1215 deg. Cent. The metal was not of special purity and its ductile-brittle transition temperature was given as 315 deg. Cent. Both tensile and stress-rupture properties were inferior to those of molybdenum and of tungsten tested in the same way (44). Although chromium base alloys have attractive high-temperature properties, a lack of room temperature ductility has impeded their practical development. A study has been made of the transition temperature of chromium binary alloys with twenty-one different elements. In conformity with general experience, it was found that the addition of a second element to chromium caused a rise in transition temperature. The only exception was ruthenium with which an immediate decrease was observed. Usually, there was a rapid increase to a maximum followed by a decrease (though rarely to the original value) with further additions of the alloying element. A correlation was attempted between rate of change of the transition temperature with increasing alloy content and the electron configuration of the solute element (14).

LIGHT ALLOYS

The ultimate grain size of annealed aluminium alloy sheet containing 1·25 per cent of manganese is affected by the application or omission of an initial thermal treatment to the ingot. It was found that if no homogenising treatment was applied to the ingot, the rolled sheet contained a fine, highly concentrated precipitate which resulted in a coarse grain size, raised the recrystallisation temperature and strengthened the alloy (49). Other papers on aluminium dealt with grain boundary movement in bicrystal tensile and compression specimens of aluminium (43); and on the development of generalised expressions for the effect on the tensile properties of airframe materials, at different temperatures from atmospheric to 200 deg. Cent., of time-temperature exposure histories within the range room temperature to 260 deg. Cent. and 1 to 1000 hours (23).

Among the most important magnesium alloys for use at raised temperatures are those containing thorium, and the constitutional diagram for magnesium-thorium alloys has been determined up to 70 per cent of thorium. The maximum solid solubility of thorium in magnesium is 4·5 per cent at 582 deg. Cent. falling to a low value at room temperature, with separation of Mg_5Th, which forms a eutectic with magnesium at 42 per cent of thorium. The solubility of thorium in magnesium is not appreciably affected by the presence of 1 per cent of zirconium (55).

TITANIUM ALLOYS

Commercial titanium exhibits excessive grain growth when annealed after critical deformation (8 to 12 per cent reduction in thickness by cold rolling). Normal recrystallisation takes place when annealing follows cold rolling in excess of 20 per cent reduction in thickness (1). Hydrogen as an impurity in titanium and its alloys has a deleterious effect on their mechanical properties. Hydrogen can be absorbed at various stages of processing and can be removed by heating *in vacuo*. The additional cost of this might be avoided by better process control. An important source of hydrogen contamination is acid pickling. Hydrogen pick-up by acid pickling in predominantly alpha alloys is characterised by the formation of thin surface layers of titanium hydride, but in predominantly beta alloys no such surface layer is formed, and there is rapid hydrogen penetration with the possibility of very high hydrogen contents. The hydride layer formed on alpha titanium is stable on heating for short times at temperatures up to 100 deg. Cent. At higher temperatures the hydrogen diffuses into the core and may make a substantial contribution to the total hydrogen content. It thus appears best not to heat acid-pickled material after descaling since heating will result in deeper penetration of hydrogen (38). The mode of hydrogen precipitation in alpha titanium and alpha titanium alloys has been determined. Under favourable conditions of precipitation and growth the hydride appears as thin needles along slip planes and twin markings where the surface energies are higher than in surrounding areas (34). Mechanical properties of a series of high-purity titanium alloys containing up to 24 per cent of vanadium were interpreted on the basis of time-temperature-transformation diagrams. Increasing vanadium in alpha alloys resulted in higher strength and notch sensitivity with lower ductility and impact resistance. A quenched 11 per cent vanadium alloy was, however, exceptional in showing a low ratio of yield strength to tensile strength and a reduction of area of nearly 80 per cent. Good ductility and impact resistance were also associated with the

* The figures in parentheses refer to the number of the American Society for Metals, 1957 (Vol. 50), preprint.

completely beta structure of the quenched alloys containing 20 and 24 per cent of vanadium, though the aged structure showed embrittlement (26). Niobium has a relatively strong solid-solution strengthening effect in alpha titanium, but beta titanium containing niobium is soft and ductile, the quenched alloys showing minimum yield and tensile strength with maximum uniform elongation at about 35 per cent of niobium. Alloys containing 20 to 35 per cent of niobium could be appreciably hardened by quenching from the beta field followed by ageing (15). The properties of a titanium-base sheet alloy containing aluminium 4, molybdenum 3, and vanadium 1 per cent, have been determined. When solution treated at 840 deg. to 900 deg. Cent. the alloy showed a 0·2 per cent yield strength of 38 to 40·2 tons per square inch, maximum stress of 60·2 to 62·5 tons per square inch, and an elongation of 13 to 18 per cent. After suitable ageing treatment the yield and tensile strengths rose to as much as 73·6 and 87 tons per square inch respectively with 6 per cent elongation. Fully heat-treated sheet exhibited good creep resistance at 425 deg. Cent. Results appear to show that the sheet was not readily weldable by present fusion welding technique (45).

Rarer Metals and Alloys

Tantalum and niobium were shown to form a continuous series of solid solutions. The liquidus and solidus (with only a small difference between them) followed a smooth curve from the melting point of niobium (2420 deg. Cent.) to that of tantalum (2940 deg. Cent.). Lattice parameter values showed no deviation from a straight line and there was no evidence of any intermediate phase at lower temperatures (54).

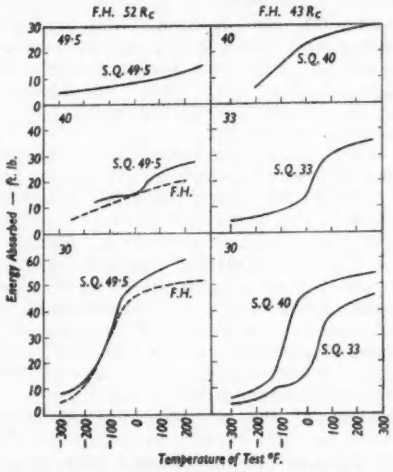
One of the most effective alloying elements in improving the properties of thorium is carbon with which it forms a monocarbide. The addition of carbon to thorium increases the hardness and tensile strength without seriously reducing ductility. The solubility of carbon in thorium falls from 0·91 per cent at 1215 deg. Cent. to 0·57 per cent at 1018 deg. Cent. with a further decrease to 0·43 per cent at 800 deg. Cent. and 0·35 per cent at room temperature (7). The constitutional diagrams of thorium-zirconium and thorium-hafnium alloys have been determined (24).

Uranium bars which are subject to repeated cycles of heating and cooling may change shape. In rolled rod this takes the form of elongation or "growth" in the direction of working. Several papers deal with this phenomenon. The growth is shown to depend on the rolling temperature, amount of rolling reduction and the condition of the material before rolling. For material initially in a randomly oriented condition, such as follows heat-treatment in the beta region (for example, 700 deg. Cent., water quenched), the rate of growth on thermal cycling in the alpha-phase temperature region is lower than for material having initially a strong preferred orientation (56). For any appreciable growth to occur, the upper cycling temperature must be above 350 deg. Cent. In general, the greater the temperature range, the greater the growth. Minimum rates were obtained with fast heating and slow cooling (37). Changes in microstructure accompanying thermal cycling of uranium were described (35) and a "thermal ratchet" mechanism suggested to explain the process of growth (17). Hydrogen in uranium causes porosity in castings and loss of ductility through the precipitation of hydride in the form of platelets. It also tends to diffuse to the surface of metal parts and disrupt protective coatings. In view of its deleterious effect, the relationships in the uranium-uranium hydride-hydrogen system were studied and rates of diffusion of hydrogen in uranium were determined (36). Small additions of titanium to uranium improve its mechanical properties and resistance to corrosion. The best all-around improvement in mechanical properties, including impact value, was obtained in the 0·53 per cent titanium alloy, water quenched from 800 deg. Cent. An increasing degree of brittleness sets in when titanium exceeds 1 per cent. A precipitation hardening treatment may raise the tensile strength, but causes a rapid fall in ductility and impact figure (40).

The zirconium-uranium system has been investigated by hot-hardness tests (2) and by a study of its isothermal transformations (20). Zirconium-uranium alloys of all compositions can be prepared by powder metallurgy methods (30). Transformation kinetics and mechanical properties of zirconium-titanium and zirconium-tin alloys were also studied. The alloy with the most promising properties in each system appeared to be the one with 5 per cent titanium or 4 per cent tin (19).

Impact Properties of Slack-Quenched Steels

Slack quenching of a steel occurs if the rate of cooling is insufficient to prevent the formation of decomposition products of austenite at temperatures above that at which the austenite→martensite transformation starts to take place. On account of mass effect some degree of slack quenching is inevitable in the heat treatment of heavy forgings, but sometimes in dealing with smaller sections it is deliberately chosen as a means of avoiding the risk of cracking. It is accompanied by a fall in the ratio of yield to tensile strength with little, if any, adverse influence on elongation and reduction of area, but its most marked effect is upon the impact properties. The transition temperature from ductile to brittle fracture in the notched-bar impact test is progressively raised by the presence of increasing amounts of slack-quenched structures.



The number underlined is the actual Rockwell "C" hardness of the steel as tested: *FH*=fully hardened, *SQ*=slack quenched, followed by the Rockwell "C" hardness number in the quenched condition, before tempering (if any).

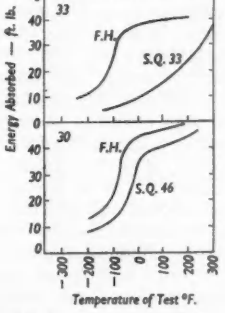
Fig. 1—Effect of slack quenching on the impact properties of steels containing (left) carbon 0·38, total alloy 0·85 per cent, and (right) carbon 0·19, total alloy 1·63 per cent, both with boron additions

In order to obtain a quantitative evaluation of the effect of slack quenching on the impact properties of some alloy steels, M. R. Meyerson and S. J. Rosenberg* have developed a modified end-quench procedure for heat treating impact test specimens with the object of producing uniform and accurately controlled slack-quenched microstructures and hardnesses at the locations where notches were to be placed. The steels used in the investigation varied in carbon content from 0·19 to 0·49 per cent with manganese about 0·9 per cent and alloy elements adjusted in amount so as to raise the hardenability of the lower carbon steels and lower the hardenability of the higher carbon steels. Thus, in passing from the 0·49 per cent carbon steel to that containing 0·19 per cent, the nickel content was increased from 0·22 to 0·68, chromium from 0·30 to 0·86 and molybdenum from 0·08 to 0·32 per cent. Each heat, containing about 0·06 per cent of aluminium, was split during pouring and boron (0·0017 to 0·0024 per cent) was added to one half of the melt. Jominy hardness tests were made on all the steels, and the distances from the quenched ends at which the hardenability curves of the various pairs of steel intersected were determined. Impact tests were made on Charpy V-notch specimens of pairs of steels slack-quenched to the hardness corresponding to the intersection of their respective Jominy curves, both in the slack quenched and the subsequently tempered conditions. Specimens for slack quenching were rough machined to 0·42 in square by 2·56in long, held rigidly in a quenching fixture consisting of a ¼in steel plate with eight holes to accommodate eight specimens, and immersed vertically into a still quenching medium. They were then stress relieved at 120 deg. Cent. and ground equally on each side to 10mm square. A hardness survey was made on the face to locate the position of the notch. After the notch had been cut, the ends of the specimen were cut off to bring it to the right length. Impact tests were carried out at temperatures from −320 deg. to +300 deg. Fah. (−195 deg. to +149 deg. Cent.). The impact properties of some of the slack-quenched steels were compared with those of their fully hardened and tempered counterparts. Results were shown in a large number of diagrams. A few of the curves are reproduced in Figs. 1 and 2.

When the steels were slack quenched at equal cooling rates to equal hardnesses and tested at those hardness levels, the impact properties of the higher carbon lower alloy steels of a pair were always inferior to those of the lower carbon higher alloy steel, regardless of whether or not boron was present. (Compare middle panel of Fig. 2 with middle right panel of Fig. 1.) The greater the difference in carbon and alloy content, the greater was the difference in impact properties. Tempering usually improved the properties of both and reduced the difference between them.

The hardness level to which any individual steel was slack quenched influenced its impact properties markedly. As slack quenched only the higher the hardness, the lower were the impact properties. Tempering, however, reversed this order in that the steels originally slack quenched to a higher hardness and then tempered to a lower hardness had impact properties superior to those of the same steels originally slack quenched to a lower hardness and then tempered.

The impact properties of all slack-quenched steels as tempered to 40 R_c were considerably improved when the steels were tempered to 30 R_c. At equal hardness levels the impact properties of the slack-quenched steels, either tempered or not tempered, were generally inferior to those of the fully hardened and tempered steels. The extent of the deterioration in impact properties caused by slack quenching depended on the difference between the hardness of the steel as fully hardened and as slack quenched. When the tempered slack-quenched steel had an initial hardness near to the maximum possible, the impact properties were but slightly affected. As the initial hardness of the slack-quenched steel became lower, the deterioration in impact properties of the steel after tempering became more pronounced.



See note below Fig. 1.

Fig. 2—Effect of slack quenching on the impact properties of steel containing carbon 0·49 per cent, total alloy 0·60 per cent

* *Journal of Research*, U.S. National Bureau of Standards, October, 1957, page 273.

LETTERS AND LITERATURE

Letter to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

"AUTORAIL RAPIDE" AND "THE TALISMAN"

SIR,—There are one or two comments I would like to make on the article comparing the Trans-Europe Expresses with the "Talisman" and the pre-war "Silver Jubilee," that appeared in your issue of November 29.

First, there is no such thing as "an Eastern Region 'Pacific' of the 'RA9' class." This classification points out route availability of the locomotive only. The correct designation of Sir Nigel Gresley's "Pacifics" is class "A4." While the "Silver Jubilee" was initially a seven-coach train, it was found subsequently that the "A4" "Pacifics" had power in hand on this service and an extra coach was added. This raised the tare weight of the train to 248 tons and correspondingly increased the passenger accommodation. The figures given by your correspondent are not, therefore, representative of this train in its final form immediately before the war.

P. W. B. SEMMENS

Middlesbrough,
December 16, 1957.

Book Reviews

The Solidification of Castings. Second edition. By R. W. RUDDLE. Institute of Metals, 17, Belgrave Square, London, S.W.1. Price 42s.

A KNOWLEDGE of how metals solidify is of great importance to the foundryman, for the soundness of a casting is largely governed by its method of solidification. The older method of making a casting was that of trial and error. Anything which can reduce the period of "trial" will reduce production cost in equivalent degree. In recent years, increasing attention has been given to the scientific aspects of the design and production of castings, as may be seen by reading Mr. Ruddle's book. The first edition appeared in January, 1950; the new edition of May, 1957, is nearly four times as large and contains little of the original text. It summarises and critically surveys the researches studying the mechanism by which castings freeze, and the rates at which freezing occurs. A list of references covers 306 research papers and articles, which are discussed; unfortunately, in nineteen instances, a wrong reference number is given in the text. The book is intended primarily for the research worker and the advanced foundry technician, but it is said that "much of it should be of considerable interest to the practical foundryman." For the first two categories it is clearly an indispensable source of reference; but the index is very poor and a number of effects attending the production of castings are not discussed, or are inadequately dealt with.

The foundryman regards solidification shrinkage—the volume lost in changing from liquid to solid at the freezing point—as the major factor causing unsound castings; and his main efforts are directed to adequate feeding—getting more liquid metal to the place where the shrinkage occurs. He must therefore know the amount of solidification shrinkage for the particular metal or alloy, and anything else about the mode of solidification which will help him in feeding. But, in the index to Mr. Ruddle's book, the terms "shrinkage," "solidification shrinkage" or "contraction" are not to be found; nor is a table of solidification shrinkage values for various metals and alloys included. "Fins" or "flashes"—those fin-like appendages caused by leakage of the metal (as at parting planes) from the casting into the mould—are discussed on pages 208–9, but only in reference to cooling; it being said that "the fin will freeze completely long before the main body of the casting is solid." There is no reference to the common consequence of this effect, a "hot tear," because the solid fin is in contact with semi-solid metal; and, when this solidifies in turn, and endeavours to contract, it is not free to do so. The possibility of a hot tear *might* be deduced from the statement quoted, but it would have been better to say so. The index should at least cite page 208 under "hot tears," but doesn't; nor does it refer to page 293, where internal hot tears are discussed.

If the foundryman makes castings of aluminium bronze, he wants an explanation for the pronounced piping found in castings of this alloy, and he may consider this to be due to its high solidification shrinkage. Actually, this effect is less marked than in many other copper-base alloys, and the reason for the piping is probably the very narrow solidification range. In discussing copper-aluminium alloys, however, the index refers to neither matter. It does not list "segregation" or "inverse segregation"; and there is no mention of the inverse-segregation effect known as "tin sweat," so familiar to the foundryman. In the practical part of the book the author assumes that the metal cast is essentially gas-free, and that "gas porosity does not enter into the matter." Of course, it often does, but it should be described as "porosity" only when the cavities are interconnected. If they are not, the effect should be described as "gas unsoundness." This again is often advantageous. In copper-aluminium alloys the presence of such gas-holes serves to counteract solidification shrinkage, giving rise to general unsoundness rather than a localised cavity; such gas-unsound castings being, indeed, often hydraulically sounder than gas-free castings. Similarly, in rimming steel, the deep central pipe shown by normal ingots is prevented by the controlled liberation of bubbles of carbon monoxide gas in the semi-solid mass, in total volume compensating for the solidification shrinkage. Since the gas-holes weld up in rolling, a much greater proportion of the ingot than with a piped ingot can be used, for sheets, strips, tubes, &c. Although the book discusses the solidification of steel extensively, rimming steel is not referred to. From a superficial examination of the book the foundryman may thus consider that it will not be of much use to him. If, however, he is not deterred by its neglect of matters apparently essential for successful practice, and decides to go through the book, he will find much information which can profitably be applied in production.

Chapter I describes the chief experimental methods for studying the solidification of castings. Chapter II discusses qualitatively the mechanism of solidification, including grain refinement and the macrostructures shown by different metals and alloys, this chapter being chiefly intended to promote understanding of the quantitative matters discussed later. Chapter III consists of a very difficult mathematical treatment of heat flow in solidifying castings and in moulds; approximation methods, which have great potentialities in this field, being treated at length. One can omit this chapter and still understand the rest of the book. Chapter IV reviews experimental work on heat flow in sand and ingot moulds, of essential importance, because solidification rates in castings depend almost entirely on the rate of heat removal by the mould. Chapters V and VI describe the effect, on freezing rate, of the shape and size of the casting, the thermal properties of the material, and other factors—for sand and chill castings, respectively. Chapter VII discusses rates of heat flow and solidification in making ingots by continuous casting.

These seven chapters, although dealing mainly with the results of fundamental research, have a number of contacts with practice. Thus, one commonly considers that, during freezing, the solid and liquid parts of a casting are separated by a sharp plane of demarcation—the solidification front—which advances steadily from the surfaces. It is important to appreciate that this "skin-forming" mode of solidification, described on page 37, and characteristic of pure metals, is not that normally shown by solid solution alloys, which are much more frequently being dealt with. As seen on page 41, freezing begins in these by the advance from the mould walls of a "nucleation" or "start-of-freeze" wave, corresponding to the liquidus isotherm; this being followed by a second "end-of-freeze" wave, corresponding to the solidus isotherm. With alloys of wide freezing range (e.g. 100 deg. Cent.) the whole casting may be thus in a state of partial solidification, or "pasty condition," during most of the freezing period. As shown later in the book, these differences in mode of solidification have important consequences from the viewpoint of feeding. The theoretical part of the book contains other practical information. On page 51 there are three instructive diagrams showing four stages in the freezing of three different kinds of alloy. The freezing of grey and nodular cast iron is usefully discussed on pages 64–71. One notes, on page 169, that the presence of a mould dressing can greatly prolong the period of solidification of a casting.

Practice is specifically covered, however, in Chapter VIII, which should be closely studied by the foundryman, for it shows the way in which the "basic" information can be applied to produce sound castings; indeed, the book should be worth buying for this chapter alone. It covers the methods of gating and running producing the "directional solidification" of skin-forming alloys necessary if the casting is to be sound. The factors affecting soundness in castings of alloys freezing in a pasty manner, and the best methods of feeding them, are also fully discussed. For various alloys there is much information on the design, shape and size of feeders, their effective range and the means of improving their efficiency. A number of valuable diagrammatic figures show different methods of solidification and the type and location of the resulting porosity or shrinkage cavity. There are two lengthy appendices covering: (I) The Thermal Properties of Metals and Mould Materials;

(II) Mathematical Functions. The improvements which could be made in a further edition of the book will already be sufficiently obvious. It will be appreciated that the author has deliberately restricted his treatment to the physical aspects of solidification, and that any attempt to cover the gas reactions occurring in the freezing of castings would increase its size considerably.

Metallurgical Reviews. Volume I, 1956. Institute of Metals, 17, Belgrave Square, London, S.W.1. Annual Subscription 42s. 6d.

LAST year the Institute of Metals started the publication of a new quarterly periodical *Metallurgical Reviews*. With the first number, which contained papers on "Mechanical Properties in Relation to Design Requirements" and "The Principles of Continuous Casting of Metals," it became evident that the publication would be of interest not only to metallurgists but also to users of metals and engineers connected with the non-ferrous industries. This is borne out by the contents of the complete volume for 1956, comprising twelve authoritative reviews each with an extensive list of references. The subjects dealt with include "The Continuous Measurement and Control of Gauge in Strip Rolling" and "Corrosion Fatigue." The first of these papers emphasises the increasing importance of radiation methods of continuously gauging strip and of automatic control which is just beginning to come into regular practice. The other paper mentioned above summarises the advances made in the study of corrosion fatigue since it was first recognised by Professor Haigh of the Royal Naval College in 1917. From the practical point of view the designer's knowledge must still be based on corrosion fatigue tests which imitate service conditions as closely as possible, and thus give at least an order of merit for a number of alternative materials. Protective measures against corrosion fatigue (dating from the use of galvanised wire for paravane towing ropes during the first world war) become particularly important, and these are discussed at some length. Other reviews are of more purely metallurgical interest but mention must be made of a valuable contribution by Dr. A. H. Cottrell on the "Effects of Neutron Irradiation on Metals and Alloys." The changes brought about in the mechanical properties of metals during irradiation, and more permanent changes in the properties of irradiated metals are clearly matters of great importance to nuclear engineers. The number of reviews written by experts for non-specialist readers has increased enormously in recent years, but the Institute of Metals is justified in its policy of adding to this number by the high quality of the contents of this volume.

Engineering Materials, Machine Tools and Processes. Third Edition. By W. STEEDS, O.B.E., A.C.G.I., B.Sc., M.I.Mech.E. Longmans, Green and Co., Ltd., 6 and 7 Clifford Street, London, W.1. Price 35s.

THE new edition of this book, like its predecessors, is intended to help students, apprentices and others in the engineering industry, to acquire a knowledge of the basic branches of mechanical engineering other than design. It covers a wide range of subjects in a clear comprehensive way which will give its users a good superficial knowledge where fully detailed information is not required. The principal additions in the new edition include notes on isothermal transformation diagrams; titanium; air gauging and multi-dimension gauges; transfer machines; contour copying machines; and tracer control of machine tools.

Rules and Regulations for the Construction and Classification of Steel Ships, 1957. Lloyd's Register of Shipping, 71, Fenchurch Street, London, E.C.3. Price 42s.

ALL the chapters in this book are listed alphabetically, and the first three set forth the regulations relating to the general rules, classification and periodical survey. The remaining eleven sections, that is, from chapters D to P, are concerned with construction rules. In the first chapter the rules for building steel ships are set out and accompanied by tables giving the scantlings of the material required and the particulars of the equipment. Other chapters deal with pumping and piping; steam; internal combustion and electrical machinery; auxiliary machinery; gearing; boilers and other pressure vessels; machinery spares; electrical equipment; and refrigerated cargo installations, while the final chapter covers the requirements concerning the quality and testing of materials. Members of the various Lloyd's Committees are named and also the members of the staff, and the volume has a detailed index.

Charts for the Solution of Refrigeration and Gas Turbine Problems. By H. WRIGHT BAKER, D.Sc., M.I.Mech.E., M.I.Prod.E. Basil Blackwell, 49, Broad Street, Oxford. Price 2s. 6d.

WE discover—for there is no table of contents—that this booklet contains pressure-total heat charts for carbon dioxide, ammonia, methyl chloride, and dichlorodifluoromethane ("Freon 12"), showing the saturated liquid and saturated vapour lines separately, followed by two sections of a temperature-entropy chart for ideal air, true air, and the products of combustion of fuel-air mixtures up to 3 per cent (presumably stoichiometric). Units are pounds per square inch, degrees Fahrenheit, and "B.T.U."

Books Received

Urban Motorways. British Road Federation, 26, Manchester Square, London, W.1. Price 55s.

Across the River. By Richard Jocelyn. Constable and Co., Ltd., 10, Orange Street, London, W.C.2. Price 16s.

Fasteners Handbook. By Julius Soled. Chapman and Hall, Ltd., 37, Essex Street, Strand, London, W.C.2. Price 100s.

Aluminium in Packaging. The Aluminium Development Association, 33, Grosvenor Street, London, W.1. Price 10s. 6d.

Twilight of the Railways. By Brigadier T. I. Lloyd. Foster Groom and Co., Ltd., 23, Craven Street, London, W.C.2. Price 5s.

British Battleships. By Oscar Parkes. Seeley, Sevice and Co., Ltd., 196, Shaftesbury Avenue, London, W.C.2. Price 126s.

Electricity in Building. By A. L. Osborne. B. T. Batsford, Ltd., 4, Fitzhardinge Street, Portman Square, London, W.1. Price 25s.

Fluid Mechanics for Engineers. By P. S. Barna. Butterworths Scientific Publications, 4 and 5, Bell Yard, London, W.C.2. Price 57s. 6d.

Earth Pressures and Retaining Walls. By W. C. Huntington. Chapman and Hall, Ltd., 37, Essex Street, Strand, London, W.C.2. Price 92s.

The Journal of the Institute of Metals. 1955-56. Edited by N. B. Vaughan. Institute of Metals, 17, Belgrave Square, London, S.W.1. Price 90s.

Centrifugal and Axial Flow Pumps. Second Edition. By A. J. Stepanoff. Chapman and Hall, Ltd., 37, Essex Street, Strand, London, W.C.2. Price 96s.

Selected Speeches, 1948–56. By H.R.H. The Prince Philip, Duke of Edinburgh. Oxford University Press, Amen House, Warwick Square, London, E.C.4. Price 12s. 6d.

Technical Reports

Corrosion Behavior of Aluminium Alloys in High-Temperature, Pressurized Water. By Alan B. Riedinger. Knolls Atomic Power Laboratory. Office of Technical Services, Department of Commerce, Washington, 25, D.C., U.S.A.—Existing data on the corrosion of aluminium alloys in hot water under pressure are summarised. The rate of corrosion is stated to increase with temperature, velocity and pH. According to the report, phosphoric acid and the polyhyroxyanthraquinone compounds inhibit corrosion.

Studies of Particle Size Distribution in Fluidized Beds. By H. M. Katz. Argonne National Laboratory. Office of Technical Services, Department of Commerce, Washington, 25, D.C., U.S.A. Price 0.20 dollar.—It is shown that both static electricity in the bed and surface adsorption of moisture affect size distribution. Experiment indicates that these effects can be eliminated by using a conducting column of conducting particles, fluidised with dry air. A qualitative relationship between minimum fluidising velocity for mixed particle sizes and pressure drop across the bed is demonstrated.

Prediction of the Pressure Loss and Density Factors for Two-Phase Annular Flow With or Without Heat Generation. By J. C. Westmoreland. Knolls Atomic Power Laboratory, Schenectady, N.Y., U.S.A.—All four combinations of laminar and turbulent flow in both annulus and core are considered. Analysis is based on assumed velocity distributions, matching velocity, and shear stress at the liquid-vapour interface. Theory is found to compare favourably with experiment on both vertical and horizontal sections. Application to natural circulation steam generators is considered.

Effect of Sodium on the Mechanical Properties of Zirconium. By J. C. Bokros. North American Aviation, Inc. Office of Technical Services, Department of Commerce, Washington, 25, D.C., U.S.A.—Zirconium structural material is reported to be used in nuclear reactors in contact with hot liquid sodium. The author states that oxide developing on the surface of the zirconium was found significantly to reduce the fatigue life at high temperatures. Hydrogen, however, was found to have very little effect at high temperatures, although it reduced fatigue life at room temperature. Exaggerated grain growth occurring in zirconium above 950 deg. Cent. severely reduced life at both high and low temperatures. The pick-up of surface oxide and reasonable amounts of hydrogen, it is stated, was not found significantly to alter the tensile properties of zirconium at high temperatures.

Research in High-Temperature Bearing Lubrication in the Absence of Liquid Lubricants. By C. H. Bailey and S. S. Sorem. Progress report No. 7, February to April, 1957, Shell Development Company, Emeryville, California, U.S.A.—Some materials that form films at lower temperatures become ineffective or detrimental at higher temperatures. A phosphorus additive, triisopropyl phosphite, remains effective at 800 deg. Fah. and above. At two-thirds of the load specified by the makers, the bearing deteriorated independently of temperature in the range 700 deg. to 900 deg. Fah. under a protective atmosphere. Fatigue appears to be a problem under moderate load at high temperatures.

Standard Overseas Contract Conditions for Mechanical and Engineering Industries, General Conditions, No. 188A and No. 574A. Published by E.C.E., Geneva, and obtainable from H.M. Stationery Office. Price 9d. each, plus 2d. for postage.—The Ad Hoc Working Party on Contract Practices in Engineering, which was set up in 1951 by the Economic Commission for Europe, has recently completed drawing up two sets of "General Conditions for the Supply and Erection of Plant and Machinery for Import and Export."

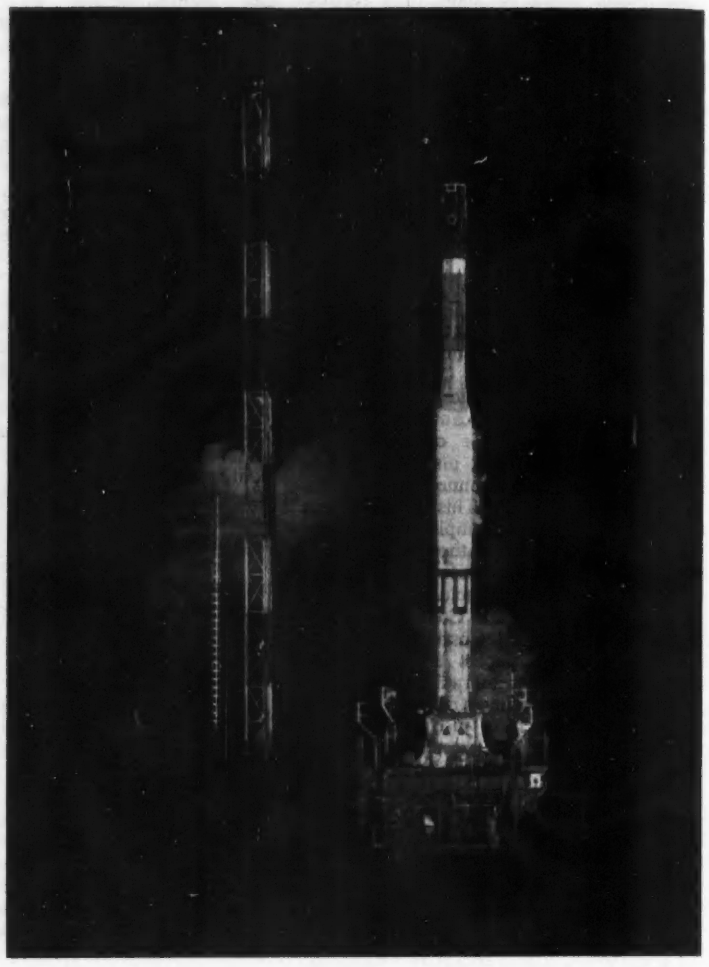
General Conditions No. 188A provide a set of conditions designed to form a basis for engineering contracts in international trade generally; General Conditions No. 574A differ from No. 188A on a few points where the conditions adopted for No. 188A were not acceptable to the Eastern European members of the Working Party, and are accordingly more suitable for East/West trade.

The earlier ECE conditions No. 188 and No. 574 were designed to fill a gap in the international exchange of plant and machinery to be erected, once bought, by the purchaser himself. The new conditions, No. 188A and No. 574A, cover the complete transactions of the supply, delivery and erection of plant and machinery. They are, in fact, the counterpart, in the field of mechanical and electrical engineering, of the conditions recently agreed in the field of civil engineering.

The new conditions may commend themselves in overcoming particular problems or in establishing connections, both inside and outside Europe, in territories where local law is not based on the Anglo-Saxon model. The conditions are already available in French and Russian, and may soon be expected to be translated into German and Spanish as well as most other European languages.

"Vanguard" Test Vehicle

The illustration on the right shows a test vehicle for the U.S. Earth Satellite Programme with the first stage motor running on test. The first stage is an improved "Viking" rocket, and the sections housing liquid oxygen can easily be detected: the single combustion chamber is pivoted, a form of control much favoured in American practice. The second stage runs on white fuming nitric acid and unsymmetrical dimethyl-hydrazine, and also uses a gimballed chamber. Contained within the black casings to which the leads run is the third stage, a solid rocket devoid of guidance: it is spun about its axis to endow it with stability before being separated and fired



The satellite is carried on the "bottle" of the third stage, and detached forcibly when the vehicle is in an orbit. Above, left, can be seen a miniature satellite, a 6in sphere instead of the 22 lb load of "Vanguard" proper: the separation device is surrounded by four sockets into which fit the struts locating the casing. The sphere is equipped with a radio transmitter and with cells sensitive to solar radiation: the bottom picture shows one being subjected to vibration testing, mounted and secured as it would be in the vehicle. The first attempt to attain an orbit under this programme failed due to a malfunction of the first stage motor when the vehicle had barely left the ground: the conflagration of the propellants destroyed the rockets, but it is reported that the sphere itself was rescued

Consulting Firm's Centenary

THE British engineering industry has a long history behind it. We ourselves have served it for two years over a century, and there are many engineering firms with over a century of service to their credit. Amongst them, however, there are few who are concerned purely with consulting work, and the professional engineering firm, generally speaking, is of later origin than the manufacturers or contractors. Last week, a Westminster firm of consultants, Messrs. Freeman, Fox and Partners, celebrated its centenary. There are now ten consulting firms, as far as we are aware, which are a hundred years or more in age, the oldest dating from 1725. Freeman, Fox and Partners is associated in the minds of most civil engineers primarily with long-span bridges. But in the nineteenth century the firm was principally concerned with the construction of railways, which was, indeed, the major occupation of civil engineers in that period. Railway work still forms part of the firm's business, including, for instance, consulting work for railways in Rhodesia, as well as the civil engineering side of power station construction, and hydro-electric design. But it is for advanced design in structural steel that the firm is now best known.

Sir Charles Fox—like many another founder of a consulting firm—was a contractor. His firm—Fox, Henderson and Co.—contributed much to the development of railways and other engineering projects in the eighteen-forties and 'fifties. This contracting firm's greatest work was undoubtedly the detailed design, fabrication and erection of the Crystal Palace in 1851 in the fantastically short space of eight months. Fox received his Knighthood for this work.

The first half-century of the firm saw great activity in railway construction, both at home and overseas. The last decade of the nineteenth century—which may be cited as an example of the firm's work in that period—saw the building of the Snowdon Mountain Railway and the Marylebone to Rugby section of the Great Central Railway, and the start of what is now known as the Rhodesia Railways system. Also, between 1896 and 1900 the firm was responsible for the first tube railway in London, the Central London or "twopenny tube," from the Bank to Shepherd's Bush.

Douglas Fox was the elder son of Sir Charles, and became a partner in the firm when it was founded. He received a knighthood in 1866, for work on the Mersey railway tunnel. In 1899, he became president of the Institution of Civil Engineers. His presidential address was, in effect, a review of engineering in the nineteenth century, a singularly fertile period which, Sir Douglas pointed out, had witnessed the establishment of civil engineering as a learned profession, and its rise to a high rank intellectually and socially. He gave examples of "the numberless works of the civil engineer, which will ever mark this century as a period of bold conception and masterly execution." Nevertheless, he warned that the time had passed when British engineers were sought in every country for advice; "the well-matured and State-aided scientific education of the Continent has changed all that, and we have now much to learn from foreign engineers, notably from those of France, Germany, Italy and Switzerland, as well as from our cousins in America." He was also forceful in his criticism of legislation which hampered the development of new ideas; he cited particularly British backwardness in using electricity, especially for tramways, for which he blamed unfortunate by-laws and controls. His assessment of the most immediate problems of development at that time still arouses great interest; some of these problems—for instance, his insistence on "solving the great problem of London fogs"—are still with us. He concluded with a prescient glance forward into the twentieth century. "The problems now opening up to the civil engineer are of surpassing importance. Trunk railways through Russia, China, Persia, Africa; irrigation works to supply the wants of growing populations; harbours large enough to receive vessels of the future (already eclipsing the 'Great Eastern,' of which the chief shortcoming was that she was before her time); central installations to furnish lighting, power, traction, and heating to whole counties; the extension of the telephonic communication—with and without wires; the abolition of the smoke and smell of cities; the replacement of horses by mechanical power in the streets; the increase of the speed of trains to 100 m.p.h.; the erection of buildings of great height where land is available; the utilisation of waste products, especially the refuse of cities; the improvement of the water supply; the reclamation of land; the profitable working of deep seams of coal."

The Design of Steel Bridges

Fame as designers of steel bridges came to the firm only in the present century. Ralph Freeman joined the firm in 1901 (he became a partner in 1912 and was knighted in 1947), and in the period 1902–05 the famous Victoria Falls bridge was built.

In 1922 the firm was retained by British contractors to prepare tender designs on their behalf for Sydney Harbour bridge. The contract was awarded on one of the firm's designs and thereafter Ralph Freeman was personally appointed consultant to the contractor (Dorman Long and Co.) to advise on all aspects of design and erection.

Between 1928 and 1939, the firm, under Freeman's direction, was responsible for a number of other important bridges, among them four in Africa, built with funds from the Beit Trust. Of these, the Birchenough Bridge over the Sabi River has a 1080ft single-span arch, the third longest arch span in the world, and the Otto Beit Bridge, over the Zambesi River, has a single suspension span of 1050ft.

These two bridges are particularly noteworthy, and exemplify that functional gracefulness which is characteristic of the best of modern bridge design. To-day, after twenty years, these two bridges have an air of complete modernity. They were also noteworthy for important technical advances, notably that they were the first two major bridges to utilise high-tensile structural steel.

The Contemporary Scene

The post-war period has been one of frustration for bridge designers in this country; the national economy has defeated them. Nevertheless, British designers generally have maintained themselves in the front rank, internationally, in spite of restrictions in experience at home. Conditions now are changing, and we can hope that soon opportunities will be presented for them to tackle problems worthy of their mettle.

Thus, we find that Messrs. Freeman, Fox and Partners' (this style was adopted in 1938), most noteworthy recent achievement is the Volta River bridge in Ghana, which is shown in the illustration and for which the firm were consultants in collaboration with Sir William Halcrow and Partners.

The bridge is a steel arch of 805ft span, in high-tensile steel, and is designed for loading equivalent to this country's abnormal load specification of 180 tons. Unusually clean lines have been achieved by the design of joints in the steelwork, which are concealed; the deck is of composite steel and concrete construction.

Other works on which the firm has been engaged in recent years include a detailed design, in collaboration with Messrs. Mott, Hay and Anderson, of the Severn Bridge, a suspension bridge with a span of 3300ft, and design of civil engineering for Castle Donington and High Marnham power stations for the C.E.A. (stations at which large turbo-alternator sets of 100MW and 200MW respectively are involved), and for hydro-electric works in Wales, including the Ffestiniog pumped storage scheme.

Underground Gasification of Coal in U.S.S.R.

THE party of representatives from the National Coal Board, Humphreys and Glasgow, Ltd, Sir Alexander Gibb and Partners, and Cremer and Warner, which visited the U.S.S.R. last month to study the work being carried out in connection with the underground gasification of coal, gave a brief outline of the tour at a Press conference in London on Tuesday, December 17. It was stated that conditions for underground gasification of coal were very different in this country and the U.S.S.R., and it was difficult to compare results. Much information of interest had been obtained, however, and it would take some time to analyse the findings of the team and consider possible applications to the quite different British conditions.

The first visit was made to Tula, in the Moscow brown coalfields, where a station has been in operation since 1940 supplying gas for heating on a commercial basis to a number of manufacturing plants in Tula. The capacity of this station is 42,000,000 cubic feet per day of gas, which has about one-sixth the calorific value of coal gas. The station also operates a sulphur recovery plant in connection with gas cleaning and manufactures sodium thiosulphate. This works pioneered the development of brown coal gasification and is still used for the experimental work on which has been based the design of larger stations for power generation. The first section of one of these, the Schatzk station, near Tula, is at an advanced stage and its first section, incorporating a two-stage gas turbine, is nearly complete. This generating equipment will produce 12MW and an identical unit is being manufactured in Leningrad to double the station capacity ; plans have also been made to add at a later stage a single large unit of 24MW net output.

Another power station installation working on brown coal and due for completion early in 1958 is in Central Asia, on the River Angren, near Tashkent, and could not be visited on the tour. This Angrensk station is planned to supply gas for burning under the boilers of a conventional power station having 100MW initial capacity with plans for doubling.

The visits to the Tula and Schatzk stations were supplemented by a number of lectures on the way in which the gas channel through the coal can be established by operating from bore-holes drilled from the surface. This was done most ingeniously with a combination of air drying of the wet coal and the working back of a fire zone towards the air blast. In another technique electrodes were passed down bore-holes and used to make a connecting channel by applying a heavy electrical current. The equipment available for experimental and development work was on a considerable scale.

The next stage of the tour took the party to the new town of Stalino, in the Ukraine, where there is housed a design institute with 200 engineers working on plans for underground gasification plants. Some of these technologists had been associated with the pioneer hard coal plant at Gorlovka nearby, which conducted a number of trials until it was destroyed during the war.

Apart from the brown coal stations under construction, the Stalino Institute is designing hard coal stations for construction in the Kuzbas, in Siberia. The first of these stations now operating experimentally at Yuzhno-Abinsk produces 16,000,000 cubic feet of gas per day and preparatory work is going on for two large power stations—one at Stalinsk, planned for 400MW, and the other at Kholmogory for 1200MW installed capacity. At both these sites there are considerable reserves of coal with up to seventeen separate seams containing more than 100 million tons.

From Stalino the party went about 120 miles to Lisichansk, on the banks of the North Donets River, where there is a gasification plant on hard coal, producing some 20,000,000 cubic feet of gas per day with the use of oxygen-enriched air. The use of oxygen for producing power gas is not essential and only continues because a large oxygen plant installed at Lisichansk has a regular sale for the inert gases, argon, krypton and xenon, produced as a by-product. The station is used for large-scale experimental work, particularly on producing combustion channels electrically, in dewatering seams by pumping and on directed drilling. This direct drilling technique is regarded as one which will eventually be adopted for exploiting hard coal deposits. With it a sloping hole is drilled from the surface and intersections with the various strata are plotted. At a predetermined point the drill is directed along a curved path to enter the coal almost at a tangent and the drill is then steered along the coal seam. The direction of the hole in the coal is checked by withdrawing cores and observing the way the planes of cleavage lie in the hole. This gives an idea of the direction of the drill in relation to the way the coal is lying.

Equipment for drilling vertically from the surface and turning the bore at right angles into a horizontal coal seam is being made, although not yet in commercial quantities Under this procedure the vertical hole from the surface to the coal seam is drilled by conventional methods and cased, and a small chamber is formed at the base. A small piece of casing similar to a 90 deg. elbow joint, but hinged at the elbow so that it can be opened out to lay in a straight line, is lowered down the vertical bore in the open condition At the bottom of the bore an external projecting arm pushes the lower horizontal part of the casing into its right-angled setting facing along the coal seam. A flexible drill string is introduced through the casing for subsequent drilling in the coal seam.

The tour was completed with a series of lectures and discussions in Moscow at the Central Institute for Underground Gasification and at the Institute of Combustible Fuels of the Academy of Sciences.

The team reported that the visit and the discussions took place in a cheerful and frank atmosphere, and that the protagonists of underground gasification in the U.S.S.R. appear to be supremely confident. Their economic surveys show that, in Russian conditions, the heat in coal can be supplied more cheaply to a power station by means of underground gasification than by conventional or opencast mining, or by the new method of mining coal with high-pressure water jets and hydraulic conveying.

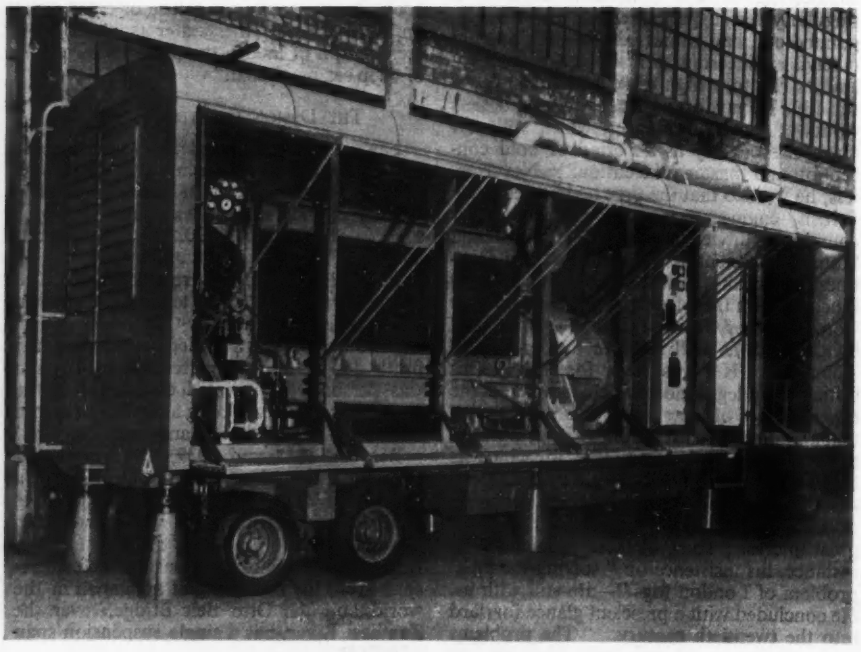
Mobile Power Houses

To provide power for driving heavy-duty pumping units during an emergency, the Metropolitan Water Board ordered from Blackstone and Co., Ltd., Stamford, eleven mobile generating sets, of which nine develop 400kW and are of 10,000 to 20,000 gallons per minute capacity, depending upon the lift of the pump. These sets, one of which we illustrate, consist of a radiator-cooled, pressure-charged, eight-cylinder, Lister-Blackstone ERS8 vertical diesel engine, developing 600 b.h.p. at 750 r.p.m. with a flange-mounted 400kW, 440V, three-phase, 50 c/s Brush alternator with direct-coupled exciters. The unit is carried on a twenty-four-wheeled trailer having a length of 30ft, a body width of 8ft, an overall height of 15ft, and a fully laden road weight of 30 tons.

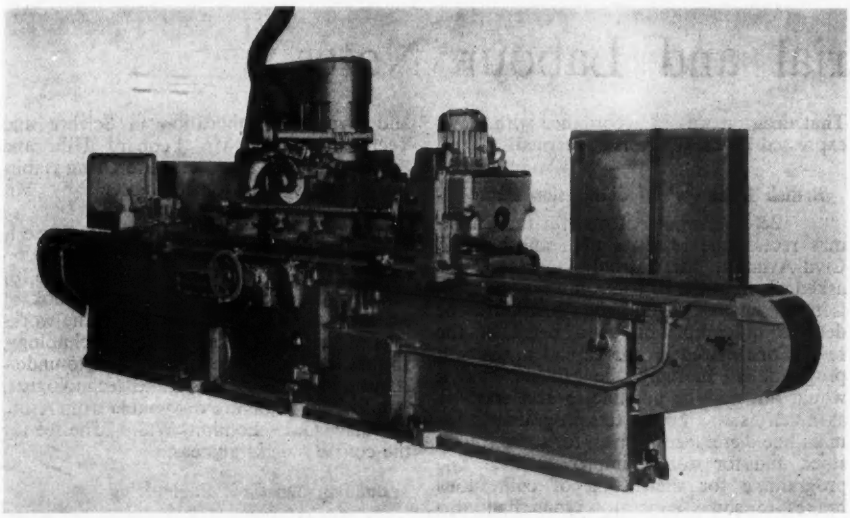
The body is of steel plating and aluminium sheet and the panelling is sectioned, the steel lower portion on each side hinging down to form an extended working platform, while the large aluminium panels hinge up and are held in position by metal struts. The engine and alternator are carried on a three-point anti-vibration mounting, and the efficiency of the method is indicated by the absence of vibration even at full load. For easy operation the engine controls are led to one side and a gauge panel is mounted over the control wheel. Starting air for the main engine is supplied from a compressed air bottle, housed directly under the Serck radiator, which is charged by a Broom and Wade compressor driven by a single-cylinder Lister diesel engine. An attachment allows for air lines to be taken to all the road wheels, the tyres of which are kept at a pressure of 100 lb per square inch. Fuel is carried in a large-capacity tank mounted under the trailer floor and filled by a hand-operated semi-rotary pump fitted with a filter.

Output from the alternator is taken to a switchgear cubicle at one end of the unit, where there is also a double tier of Wayne cable drums, each carrying 40 yards of cable. The cubicle has a built-in battery charging unit and the batteries supply lighting for the trailer at 24V and for parking lights at 12V. Six screw jacks are carried and, when on site, they are positioned under the chassis to take the weight off the wheels. The chassis is arranged for both one and two-line air braking systems and has a full-lock turntable at the towing end.

The remaining two of the eleven generator sets are of smaller power and the prime mover is a normally-aspirated, four-cylinder Lister-Blackstone ER4 engine developing 225 b.h.p. at 750 r.p.m. and driving a flange-mounted 125kW, 440V, three-phase, 50 c/s Brush alternator. These alternators are of self-regulating pattern with frame-mounted Amplidex exciters, and the trailers, which measure 23ft 9in in length by 8ft wide and 14ft high, have sixteen wheels and an overall weight of 20 tons.



400kW mobile generating set powered by a 600 b.h.p. diesel engine



Hydraulically-operated spline grinding machine with a capacity of 72in between centres and a grinding stroke of 66½in

Spline Grinding Machine

A SPLINE grinding machine with a capacity of 72in between centres which is now being made by A. A. Jones and Shipman, Ltd., of Leicester, has a useful grinding length of 66½in, the remainder of the 84in working stroke being used for run-out over the tailstock to two wheel truing positions. It has a centre height of 7in and the range of vertical adjustment of the wheel head is from 3½in to 11½in, measured between the grinding spindle centre line and the work centre line. No cross traverse of the wheel support column is provided and diamond positioning for wheel side arc truing is obtained by movement of the truing device at the end of the table.

As can be seen in the accompanying illustration, the table is supported over practically the whole of its length on the bed and the wheel head column is bolted to the rear of the bed. The wheel head is supported on a vertical slide movable through a hand-wheel operated worm wheel and screw to give feed increments of 0·050in per revolution or a fine feed in increments of 0·001in. The wheel spindle is movable axially in its bearings over a length of ½in by means of a thumb wheel for fine adjustment purposes.

A hydraulically operated indexing workhead is controlled through a notched plate and indexing pawl and has forty-eight notches for which masking plates are supplied to give the required number of divisions for different splines. This workhead incorporates interlocking mechanism to prevent table movement unless it is fully indexed and locked.

The main table motions are controlled through a joy-stick lever, movement of which in a gate increases and reduces fluid working pressure, controls table speed and engages a hand traverse wheel. A reversing lever is provided for the table and its stroking is set by three adjustable dogs, two of which are used for reversing during grinding and the third stops movement at the end of table over-run to bring the diamond truing unit to the wheel. The table is run out to the truing position by operation of the reversing lever, which renders the left-hand dog inoperative. An indexing dog, at the right-hand end of the machine, actuates a cam on the workhead and when this cam is turned through 90 deg. the work indexing movement takes place. Should the full indexing motion not be completed an interlocking arrangement comes into effect to prevent table traverse for the subsequent grinding stroke.

Gearing for Indian Navy Frigate

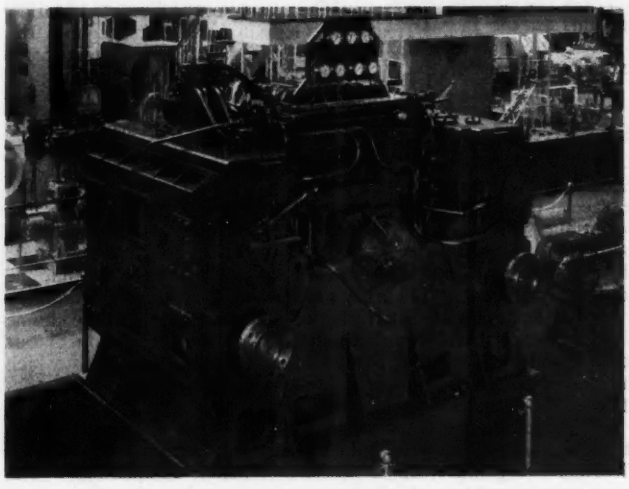
THE Royal Navy has installed two sets of multiple-diesel machinery installations, each having four engines driving one shaft through a reverse reduction gearbox, in two classes of frigates, of which the first was H.M.S. "Salisbury." A similar arrangement has been adopted for the new frigate for the Indian Navy, the I.N.S "Brahmaputra," which was launched on December 23. The ship is propelled by twin screws powered by a total of eight Admiralty S.R.I. four-stroke, uni-directional diesel engines. The power from each group of four engines is transmitted to the main shafting through a Hindmarch/MWD oil-operated, reverse reduction gear, seen in our illustration, provided by Modern Wheel Drive, Ltd., Slough, Buckinghamshire. Each unit has a reduction ratio of 4·6 to 1, and is rated to transmit continuously 7200 h.p. from the four uni-directional engines, which develop their power at 920 r.p.m.

The gear casing is of mild steel welded construction of adequate strength to carry the bearing loads and designed to provide ready access to the bearings, which are of gunmetal, white metal lined, and to ensure that the shaft assemblies may be easily removed. Inspection covers are provided in way of the gear trains. Each engine drives through a Hindmarch/MWD oil-operated clutch, which meshes with a second clutch, each clutch driving a pinion meshing with the final wheel. Engagement of one clutch or the other drives the final wheel in the ahead or astern direction, and a master control directs the oil to engage the appropriate clutch. Each engine can be isolated from the gearbox, which can be operated regardless of the number of engines transmitting power. All the oil for the gearbox is supplied from an independent pump, which draws oil from the gearbox sump and delivers through filters and a cooler.

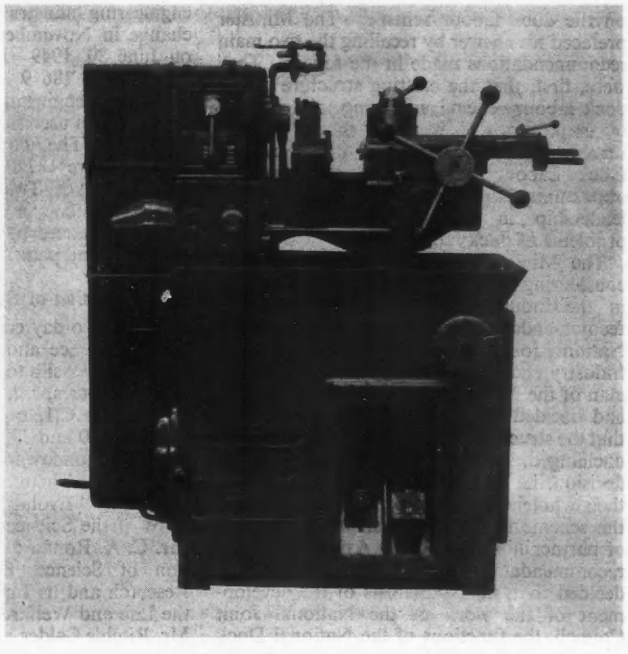
Small Capstan Lathe

A RECENT addition to the capstan lathes made by Murad Developments, Ltd., Stocklake, Aylesbury, Bucks, is the ½in capacity machine illustrated below, which has a centre height of 5in and admits up to 10in between the collet and turret face. It is driven by a motor of 2 h.p. at 2800 r.p.m. and ½ h.p. at 720 r.p.m., and is available with six spindle speeds, forward and reverse, from 355 to 5000 r.p.m.

The cross slide has a maximum distance of 4½in between tool posts and a movement of 4½in across the bed. A 4½in diameter turret can be supplied on a hand or a power-operated slide. One of the three models in which the machine is made has a lever-operated collet and hand-fed turret slide. A second model has a lever-operated collet and a power-fed turret slide, with three feed rates of 0·0025in, 0·0045in and 0·010in per spindle revolution. The third model is fitted with pneumatic pedal operation of the collet and a power-fed turret slide. The pneumatic bar feed is interlocked with the collet, so that the manipulation of one control opens the collet, feeds the bar to length and recloses the collet.



Four-engine input and single-output oil-operated reverse-reduction gearbox



Half-inch capstan lathe with power-operated turret slide

Industrial and Labour Notes

Prices

The National Union of Manufacturers, in the December issue of its monthly journal, has commented on a request to industry to reduce prices which was made by the Chancellor of the Exchequer in a recent speech. The journal suggests that this "represents a new stage in the Government's campaign against inflation," and says that the National Union of Manufacturers is not opposed to "the principle of the Chancellor's appeal." If costs, and particularly labour costs, can be held steady, the National Union agrees, then prices can also be held steady, and it says that any step which manufacturing industry can take towards holding prices steady should certainly be taken and publicly proclaimed. But, first, it is added, there must be an assurance that costs will be held steady, and the National Union thinks that it is "early days yet to say that they will."

It is true, the journal goes on to say, that the prices of some raw materials are falling. Furthermore, it is possible that other items of costs, including the all-important labour costs, may not increase by a margin greater than will offset this saving on raw materials. If they do not, and if, as a total result, the manufacturer's costs have not again risen by the spring, then surely, the National Union observes, as the merest matter of good business, he is not in any case going to raise his prices, even though he may be, as the Chancellor seems to assume, entangled in a thicket of restrictive practices. Stable prices, it is emphasised, will follow if costs are stabilised, because it is in the manufacturer's interest to keep his prices steady as far as he can. Unlike organised labour in present conditions, he has to bargain with his customers in the open market, and cannot bludgeon or threaten them in a closed shop!

Dock Labour

In the House of Commons last week, the Minister of Labour, Mr. Iain Macleod, was asked what conclusions he had reached from his consideration of the Devlin report on the dock labour scheme. The Minister prefaced his answer by recalling the two main recommendations made in the report. They were, first, that the existing structure of the dock labour scheme, involving joint control by employers and workers, should be preserved, and, secondly, that the National Dock Labour Board might be given the opportunity to exert a greater degree of leadership in dealing with the various problems of dock labour.

The Minister went on to say that after considering the observations of all the bodies in the industry and discussing the main recommendations with representatives of the National Joint Council for the Port Transport Industry and the chairman and deputy chairman of the National Dock Labour Board, he had decided to accept the recommendation that the structure of the scheme should remain unchanged. All parties accepted that decision, he added, and had assured him of their wholehearted co-operation in operating the scheme in the spirit which such a form of partnership demanded. As to the second recommendation, the Minister said he had decided that, in the interests of the development of the work of the National Joint Council, the functions of the National Dock Labour Board should not be extended, and the board would continue as at present. That decision was in accordance with views expressed by the interests concerned.

British Railways' Modernisation Plan

Before Parliament rose for the Christmas recess, the Minister of Transport and Civil Aviation, Mr. Harold Watkinson, was asked which of the British Railways' modernisation schemes would be postponed or delayed in completion as a result of the restrictions placed on the capital investment programme. In reply, the Minister said it would not now be possible to accelerate by as much as was hoped the programmes for main line diesel locomotives, for some rolling stock and for station improvements. The programme for the fitting of continuous brakes to some mineral wagons had also had to be slowed down. The British Transport Commission still hoped, however, that by maintaining and, if necessary, accelerating, its plans in subsequent years, it would be able to complete the programme by the published dates. In answer to further questions on the subject, the Minister said that the work the Commission wanted to do would cost roughly £180 million a year for the next two years, and what the Government was allowing was £170 million a year. If the Commission could not make do with £170 million, he thought it would be "lacking a sense of proportion about its capital expenditure."

Basic Materials Prices

The Board of Trade has reported a further fall of 1·7 per cent between October and November in the basic materials index. It was brought about mainly by lower prices for raw wool, raw cotton, raw rubber, lead (a fall of 3·2 per cent), imported steel scrap (a fall of 7·6 per cent), hides and skins, and zinc (a fall of 2·4 per cent). But the effect of these decreases was partially offset by higher prices for copper (a rise of 0·7 per cent), raw jute (a rise of 3·4 per cent), linseed oil (a rise of 3·3 per cent), and a few other items.

The indices for materials used in the engineering industries, however, showed little change in November. The numbers, based on June 30, 1949=100, were, at the end of November, 186·9 for materials used in mechanical engineering industries, and 179·5 for materials used in the electrical machinery industry. The comparable numbers for October were 187·0 and 179·4 respectively. The Board of Trade explains that higher prices for copper and brass items were roughly balanced by lower prices for rubber, lead, zinc and paint.

Organisation of Science and Technology

A two-day course on "The Organisation of Science and Technology" has been arranged by Aslib to take place at the College of Preceptors, 2, Bloomsbury Square, London, W.C.1, on Monday and Tuesday, February 10 and 11, 1958, commencing after lunch on Monday and ending late on Tuesday afternoon. There will be five lectures as follows :—"Evolution and Inter-relationships of the Sciences and Technologies," by Mr. C. A. Ronan ; "The Nature and Function of Science, Scientific and Technical Research and its Impact on Production, and the Life and Welfare of the Community," by Mr. Ritchie Calder ; "The Role of Organisations in Science and Technology," by Mrs. M. E. Mackiewicz ; "Publication Methods and Types of Publication in Science and Technology," by Mr. Leonard Hill, and "Mental Habits and Literature-Using Habits of Scientists and Technologists," by Mr. B. C. Vickery.

It is stated that the object of the course is to give workers in libraries and information departments, who have no experience of science, some idea of the mental outlook of scientists, and some knowledge of the workings of the world of science and technology, so that they will be better equipped to understand and serve scientists and technologists. Application forms are obtainable from Aslib, 4, Palace Gate, London, W.8. The fee for the course is eight guineas.

Building and Civil Engineering

Some of the current problems of the building and civil engineering industry were commented upon by Mr. W. G. Turriff, chairman of the Turriff Construction Company, Ltd., at the company's annual meeting on December 17. He said that, over the years, the industry had been plagued by financial crises and political emergencies. To a large extent, the industry's well-being required a long-term outlook ; it benefited neither the industry nor the public for work to be turned on and off like a tap.

Mr. Turriff went on to say that the building and civil engineering industry awaited with much interest the effects of the Chancellor's present measures which, on the face of things, appeared to point towards underemployment. But the industry was, nevertheless, encouraged by the long-awaited decision to proceed with the road programme. From time to time, he continued, there was criticism of the building and civil engineering industry in this country, and operations in the U.S.A. were often held up as examples which could well be followed. Mr. Turriff said that he had inspected construction work in various parts of the world, and it was his firm conviction that the building and civil engineering contractor here was as competent as any of his brethren elsewhere.

Motor Vehicles and European Free Trade

In his chairman's statement at the recent annual meeting of The British Motor Corporation, Ltd., Sir Leonard Lord remarked that the advent of European free trade and the progressive reduction of tariffs throughout Europe now appeared to be certain. The signing of the Common Market Treaty by Germany, France, Belgium, the Netherlands, Luxembourg and Italy committed our Government to promoting its European free trade formula in wider association with those and other European countries in order to improve our access to those important markets.

But, Sir Leonard continued, it was the home market that would have to meet the impact of this revolution in European economic policy. Therefore, he urged, there was reason and justice on the automobile industry's side when it asked the Government for a better understanding of the home market's function as the foundation of our economy. Government policies which affected home sales through credit restrictions, purchase tax, profits tax, hire purchase and other controls must be revised to give the industry parity of home conditions with those of its continental competitors. The Government, Sir Leonard observed, must make trade free to meet free trade.

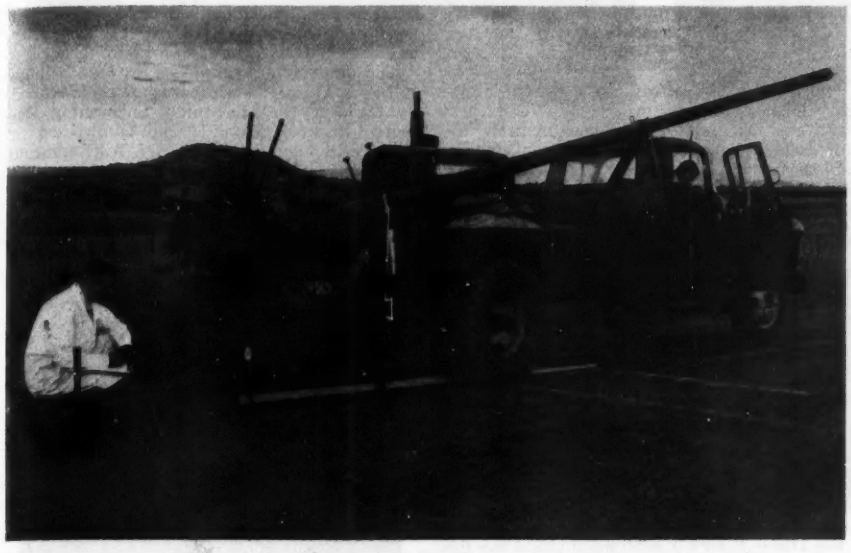


Fig. 1—Measurement of the deflection of a road under a heavy vehicle

Research in South Africa

BY OUR SOUTH AFRICAN CORRESPONDENT

THE following items of research of engineering interest relate to work being done in the laboratories, at Pretoria, of the Council for Scientific and Industrial Research.

Heat Transfer Film Coefficients for Flat Plates

The general project of which this work forms a part, embodies the study of heat transfer film coefficients relating to heat transfer between fluids and solid boundaries, with special reference to flat plates. A special heater plate was constructed to study the point heat exchange from a flat plate in an airstream, the apparatus being housed in a 10ft wind tunnel which provides the necessary uniform and directed air flow. (see Fig. 5).

During the year tests with the heater plate in a horizontal position were continued under conditions of both forced and natural convection. The former was carried out at various air speeds and, in addition to the determination of film coefficients from direct readings of temperature difference between air and plate surface and the amount of heat lost by the plate to the air, distribution of temperature and velocity in the boundary layer were measured. Modifications to the experimental set-up were required for the natural convection tests, as it was found that even the most elaborate precautions and the closing of all doors failed to suppress sporadic air movements which had considerable influence on the tests.

The results of the forced convection tests have been published in "EASA," the journal of the Engineers' Association (South Africa), December, 1955, March-June, 1956. It was shown that good agreement exists between experimental values and theory, provided corrections are applied for natural convection as well as for the unheated starting length.

Measurement of Low Fluid Velocities

Good progress has been made with the development of new instruments and methods for the measurement of very low fluid velocities. Such instruments are essential for measurements when studying, for example, the ventilation of buildings and boundary layer phenomena.

The standard hot wire anemometer has undergone further improvement and has been calibrated between 0·1ft and 16ft per second on the whirling arm. Check tests were then conducted between 11ft and 16ft per second in the 24in wind tunnel, where readings were compared with those of a standard pitot-static tube. The excellent agreement obtained showed the whirling arm method of calibration to be basically sound.

A low-speed indicator, shown here in Fig. 3, which is in principle a very sensitive aerodynamic balance, has been constructed for use in the 24in wind tunnel. This device, by which low air velocities in the working section can be accurately determined, is used for routine calibration of low-speed anemometers.

Slip-ring "Noise" and Fan-Blade Vibration

An investigation into the vibration characteristics of fan blades, which was undertaken on behalf of the industry concerned, indicated the need for developing a slip-ring unit which would make possible the transmission of signals from

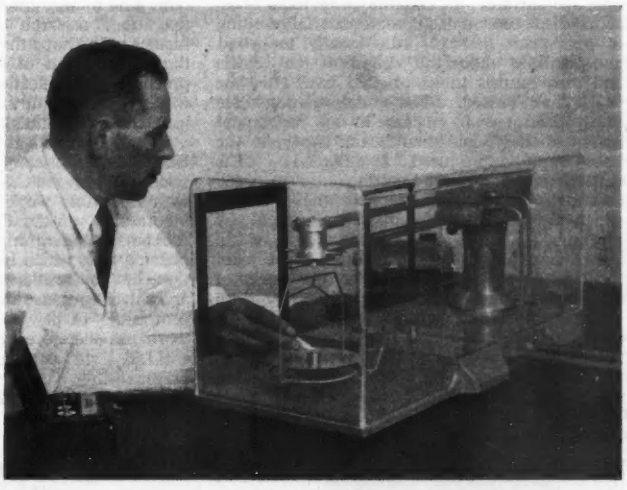


Fig. 2—A sensitive liquid manometer designed by N.M.E.R.I.

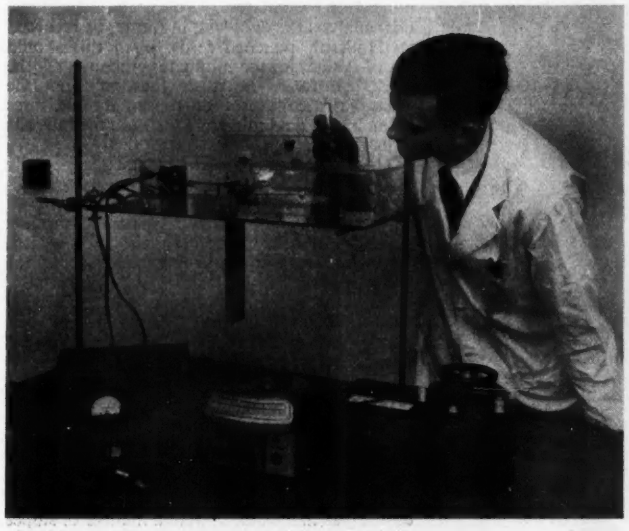


Fig. 3—Low-velocity indicator for routine calibrations of anemometers in the 24in diameter wind tunnel

Fig. 4—Equipment for determination of the electrical resistance of sliprings in the course of research into the design of electrical contacts

wire-resistance strain gauges or other pick-ups located on rotating machine members to measuring instruments. Such a slip-ring unit, incorporating seven silver slip-rings and carbon silver brushes was therefore made in the central workshops and is at present being tested to determine the " noise " characteristics of this combination of slip-ring and brush materials. Other combinations of likely materials will be tested to determine which one gives best results.

The unit is shown in Fig. 4 as set up for the determination of the electrical resistance of slip-rings in the course of research into the design of electrical contacts between moving and stationary conductors.

Road Foundation Design

The increase in the amount of heavy road transport in the Union of South Africa has led to some roads being subjected to much greater loads than those for which they were originally designed, with the result that many of the older main roads which bear a considerable volume of traffic are having to be rebuilt. In order to collect data necessary for the proper design of new foundations for these roads and for new roads which are being planned, the National Institute of Road Research has been making a study of several road foundation failures in the Standerton and Vereeniging areas.

Recent developments in road design overseas have established the importance of considering not only the strength of the soil layers in the foundation but also the deformation which is produced when a heavily loaded wheel moves over the surface. In extreme cases there is an actual displacement of the road material resulting in permanent damage, but usually the road gives a little under the weight of the vehicle and then returns to its original level after the wheel has passed. These deformations are being measured by means of an instrument known as the Benkelman Beam, shown in the photograph reproduced in Fig. 1. The deflections of the road surface are recorded as the heavy truck moves over the point on which the end of the beam is resting, and, by repeating the run for different positions of the beam across the road, a three-dimensional picture of the deflection occurring under a heavy wheel load can be obtained.

Tests carried out in the Standerton area on a number of sites ranging from good to very poor gave deflections ranging from 10 to 140 thousandths of an inch under a 6000 lb dual-wheel load. Such actual measurements in the field should lead to a much better understanding of the required performance of a road foundation.

Sensitive Liquid Manometer

In aerodynamic research it is often necessary to measure very small pressure differences with great accuracy. Such measurements are, for example, encountered in studies of boundary layer phenomena and of the resistance to flow in pipes and through materials such as wire gauze. At low air speeds, however, the pressure differences which occur are so small that manometers of extreme sensitivity and accuracy are required to measure them.

The photograph reproduced in Fig. 2, illustrates such a manometer which was developed by the National Mechanical Engineering Research Institute, Pretoria, and constructed in the C.S.I.R. central workshops. Tests indicate that the instrument is accurate to $1{\cdot}3\times10^{5}$in water gauge, that is to say, to about half a millionth of a pound per square inch.

South African Research into Rock Bursts

THE following record of an important research investigation at present proceeding in South Africa has been gleaned from personal contact with members of the research team concerned, the eleventh Annual Report of the South African Council for Scientific and Industrial Research (C.S.I.R.) and the December, 1956, issue of *The Mining Survey*, a publication issued monthly by the Transvaal and Orange Free State Chamber of Mines. Thanks are due to the C.S.I.R. and the Chamber of Mines Public Relations Departments for the accompanying photographs.

The terms of reference for this investigation, which concerns the problem of rockbursts, were originally laid down in 1952 by the Central Mining and Investment Corporation—one of the large gold mining groups—when it established an operational research team " to study the matter further in the hope that greater understanding of the phenomenon of rockbursts might indicate practices or modifications in mining methods that would reduce still further the hazards and troubles associated with mining highly stressed rock."

This first investigation was carried out at the East Rand Proprietary Mines, Ltd., by a team of scientists from the C.S.I.R., and mining officials, with laboratory work conducted in the Pretoria laboratories of the C.S.I.R. The problem of rockbursts underground is a difficult and complicated one, which has no quick or easy solution, but the results to date of the experiments and investigations already carried out appear promising. A new contract for further research work has therefore been arranged whereby the C.S.I.R. will continue the investigation for another three years. A special steering committee, consisting of members of the gold mining industry and of the C.S.I.R., will control this work on behalf of the Chamber of Mines. The research programme was laid down and the procedure to be followed will be carried through by the

Fig. 1—Typical interference " fringe pattern "

National Mechanical Engineering Research Institute (N.M.E.R.I.), which is a constituent research section of the C.S.I.R.

A valuable part of the work done in the earlier stages of the investigation was the place-and-time study, for statistical purposes, of the occurrence of rockbursts in various stopes. Since then the research operations have been extended and the recording of rockburst data on four more mines has been started. To expedite the statistical analysis the data will, in future, be recorded on Hollerith punched cards. All this should be of value in the ultimate outcome of the work. It forms essentially one, and not the least, valuable aspect of the safety measures taken by the gold mining industry in the interests of its workers.

There appears to be no doubt, and it is generally accepted that there is a shattered zone surrounding all mining excavations, which zone would appear to extend approximately some 30ft to 50ft beyond the walls. This fact is rendered evident by the network of shear planes visible in the hanging walls in particular. It appears, also, that the stresses in this zone are appreciably lower than in the adjacent rock masses, and that excavations made into the zone give rise to less severe and less frequent rockbursts than those arising from excavations elsewhere.

Based on these facts, the C.S.I.R. research team suggested, in 1953, that by fracturing the rock ahead of any working face and thus destressing it, the zone of maximum stress might thereby be transferred to the more solid rock beyond. This experimental destressing procedure was first carried out in a number of stopes of the East Rand Proprietary Mines in March, 1954. Some success can be reported on the effects of this destressing procedure and the

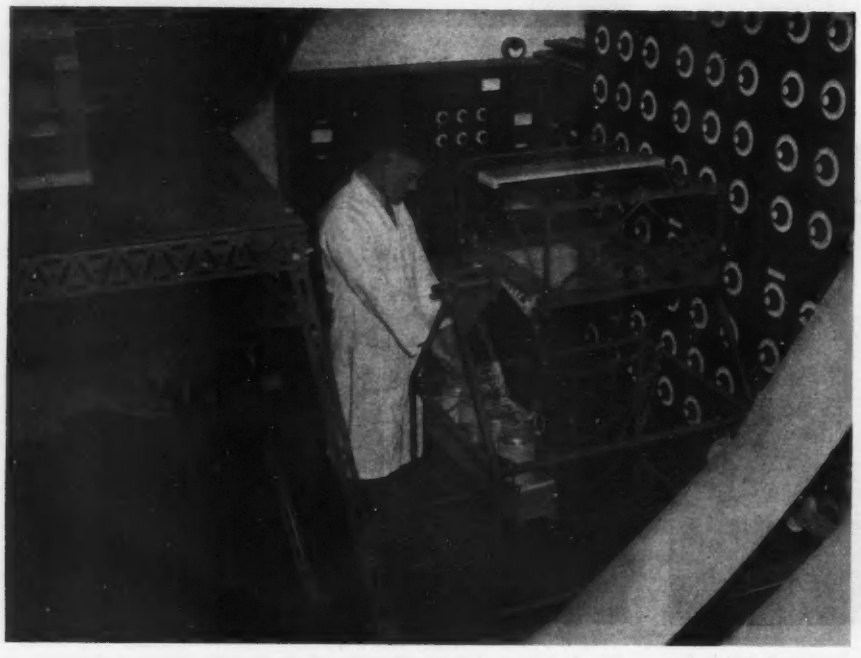


Fig. 5—A heater plate used in the study of heat transfer from a flat plate in an air stream

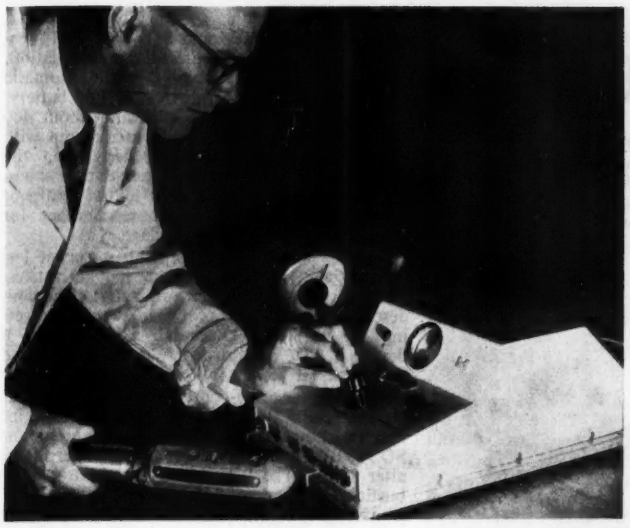


Fig. 2—Testing a "strain cell"

Fig. 3—Calibrating a "strain cell"

practice has been extended to twenty-three stopes on this mine. The incidence and severity of bursts in these stopes have been reduced, with little adverse effect on the production of ore. Nevertheless, there are so many variables and factors to be taken into account that the degree of success thus far attained has yet to be ascertained in terms of these variables.

The destressing procedure is, once a week, to drill holes about 10ft deep and from 3ft to 5ft apart into the face and thereby blast the surrounding rock. For the remainder of the week the usual work programme of drilling ore-breaking holes is followed. It appears from observed results so far achieved, that the rock ahead of the working face is being fractured and presumably destressed.

The practical application of this destressing technique, if ultimately proved successful, will obviously depend on its effect on mining economy and it may be necessary to limit its application to regions where dangerous stress concentrations are developing. Methods for the determination of such stresses, therefore, may become of paramount importance in the future application of the destressing procedure.

To this end the research team is arranging, by development of suitable equipment, to determine the change in stress by measuring the change in strain at a point in the solid rock ahead of a working face. To do this specially designed "strain cells" are being installed at the end of 50ft long boreholes drilled from a predeveloped drive some 100ft ahead of an advancing stope face. These cells can indicate strain changes in the rock in both vertical and horizontal directions. Fig. 2 shows one of the cells being tested for strain registration, while Fig. 3 depicts the process of calibration, for which purpose the cell is concreted into a hole in a cube of rock.

Sagmeters are being developed for the purpose of measuring the rate of closure in stopes, and also instruments for detecting the thickness of the zone of fractured ground around an excavation, making use of sonic principles. Preliminary tests of these devices have already been carried out.

In the N.M.E.R.I. laboratories, an extensive programme of testing has been started to obtain the linear compressive strength, creep properties and elastic constants of the various strata encountered on the Witwatersrand. By means of a photo-elastic polariscope (see Fig. 4), completed by the central workshops of the C.S.I.R., the distribution of stresses around mining excavations can be obtained by using small transparent plastic models of the excavations through which polarised light is passed. Such information will be used to verify, or otherwise, the results obtained from the mathematical analyses, and will also enable an analysis to be made of those cases for which mathematical analysis is too complex. Fig. 1 shows a typical interference "fringe pattern" obtained from plastic models under pressure. From this pattern it is possible to determine the distribution of stress in the model. The dark object in the centre is the excavation.

Other experimental techniques are being followed in the search for the solutions of the many problems associated with rockburst phenomena. For example, the behaviour of models under stress is being examined. Amongst these are models of plaster of Paris, both solid and laminated, and also models of a mixture of paraffin wax and plumber's resin. The latter substance has been found to fracture, under pressure, in much the same way as a small sample of quartzite. Another interesting model being studied is a block of a mixture of cement and wax. Fig. 5 shows this model under pressure, while a small chain-driven cutting machine slowly excavates a "stope" in the block. In each case the pattern of cracks which develop is closely studied.

Of no little importance in the investigation are the plans which have been drawn up for measuring strata movement and surface subsidence, readings in connection with which have already been started. It is considered that useful light will be cast on the rockburst problem in general by these measurements.

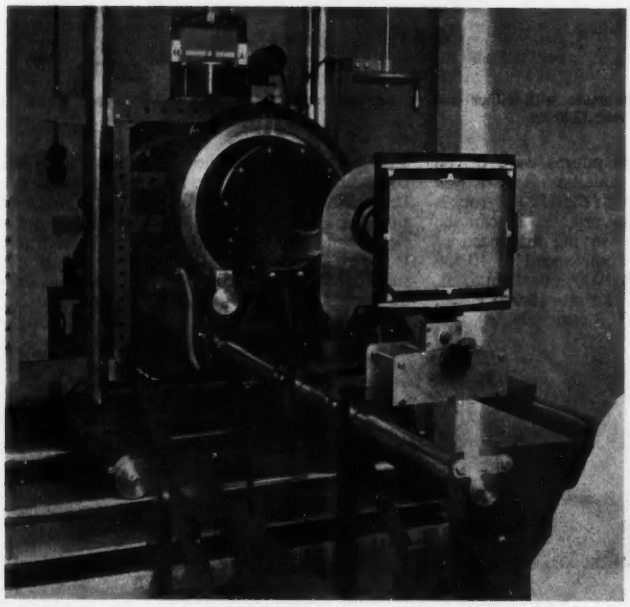


Fig. 4—Polariscope designed by the N.M.E.R.I.

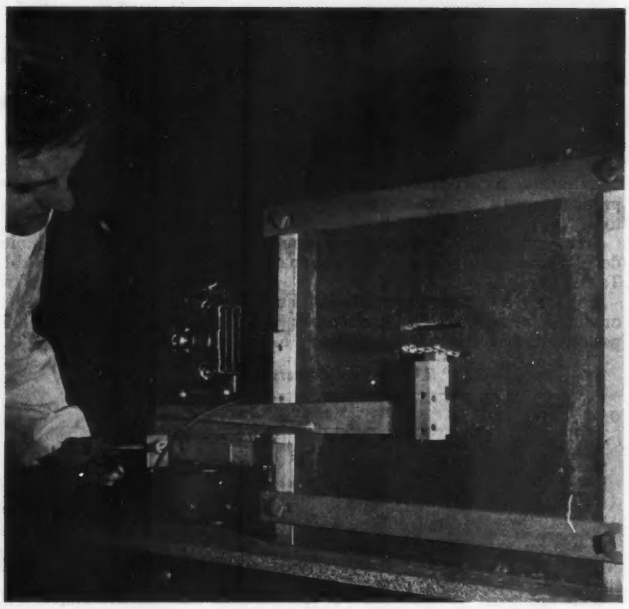


Fig. 5—Cement and wax model under pressure

French Rocket Power Units

SINCE it began work in 1944, the Société d'Etude de la Propulsion par Réaction (S.E.P.R.), 37, rue des Acacias, Paris (17c), has given special attention to three aspects of rocket propulsion, viz., propellant combustion, materials and control and feeding of the jets. In order to carry its studies into practice, it has built three test stations, at Fort des Hautes Bruyères, Villejuif (Seine); Melun-Villaroche (S. and M.), built in 1952; and Istres (B. du R.), built in 1954.

Since 1952, many of the most famous French aircraft, such as the "Espadon," "Mystère," "Mirage," "Durandal" and "Trident," have been equipped with rocket motors from the company's factory at Argenteuil (Seine and Oise). At the same time, solid fuel rockets for missiles and rocket-assisted take-off have been produced, with thrusts ranging from 1 to 25 tons.

Some of these developments, about which details have been released, are summarised in Tables I and II.

The liquid fuel rockets use as fuels "Furaline," or more recently "TX" hypergolic with 98 per cent white nitric acid as oxidiser. Kerosene has also been successfully employed. Since aluminium is not attacked by the nitric acid (a strongly adhering oxide film preventing further corrosion), the rocket motors are principally constructed from this material. Cooling of the combustion chambers is obtained by jacketing them in the fuel.

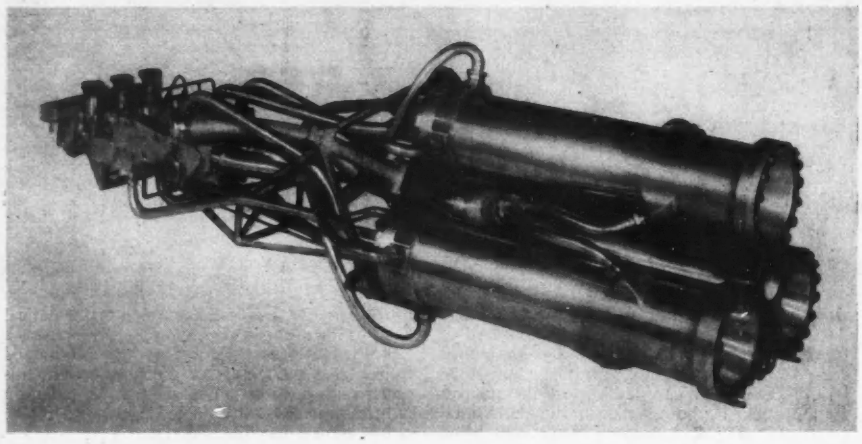


Fig.1 —S.E.P.R.481 rocket motor, as used in "Trident I." At 1200m specific consumption is 0·0048 kg/kg-sec. at 4500 kg thrust, which can be increased to 5200 kg

The motors may be grouped into two broad categories, according to whether they require external power for their fuel pumps, as in the "SO.6025," "SO.6026," and "SE.212" aircraft, or whether they are independent.[9] To the first class belongs the S.E.P.R.25, developed from 1949 onwards and first used in 1952 in the SO.6025 "Espadon," for take-off and as booster. Here the fuel pumps were driven from the main power unit, a Rolls-Royce "Nene" turbo-jet. Although the 1500 kg rocket thrust is classed as non-variable, it can be adjusted within limits by varying the speed of the turbo-jet. With a turbine speed of 10,500 r.p.m., a thrust of about 1000 kg is obtained, which increases to 1580 kg at 13,000 r.p.m. The tank pressure is low (0·2 atmospheres) and, in fact, in the SO.6025 and SO.6026, head pressure was sufficient to ensure tank pressurisation. The power plant is equipped with automatic safety devices and operates on a 24V battery. Several thousand test bed runs and about 400 flights are stated to have been carried out with this prototype design. Its derivative, the S.E.P.R. 251, is built in two separate assemblies, a feed assembly to be housed in the centre of the aircraft, and a combustion chamber for mounting in the rear of the fuselage.

To the same class of dependent rocket jets belongs the S.E.P.R.65 and its derivatives. These work on the same principle as the unit described, the S.E.P.R.65 being used for powering the SE.212 "Durandal." At 8000m it develops 825 kg thrust. Without tanks and accessories, its weight is 70 kg.

Among the self-contained rocket motors is the S.E.P.R.481 (Fig. 1). This engine became known as the main power plant for the SO.9000 "Trident I," and was no longer in use after 1955. The "Trident I" had three combustion chambers, of 1500 kg thrust at sea level, which together gave a thrust of 5200 kg at 12,000m with a specific consumption at that height of 0·0048 kg per kilogramme per second, including the turbine fuel and coolant consumption. Fuel again was "Furaline" (density 1·03), with nitric acid of density 1·52 as oxidiser, requiring an optimum fuel ratio of 2·4 : 1. The gases driving the turbine were cooled by injecting a water-methanol mixture of density 0·95. Excluding fuel tanks, the valves between the propellant tanks and engine, feed lines and mounting frame, the overall weight is 230 kg, or 258 kg in the "SO.9000." Combustion chambers of 3000 kg thrust are available, so that power units giving 6000 kg can be obtained by using either four or two combustion chambers.

The most recent units concerning which particulars have been released are the S.E.P.R.66 and its derivatives (Fig. 2). This is used in the "Mystère" and M.D.550 "Mirage I," and is built in three versions. The first has two combustion chambers of 750 kg thrust each, which may be used separately or together; the third version also has two combustion chambers, of 1500 kg each; while the second version has one combustion chamber, the thrust from which can be varied between 750 kg and 1500 kg. Consumption varies between 0·00475 kg per kilogramme per second for maximum thrust at 12,000m and 0·00575 kg per kilogramme per second for minimum thrust at sea level. Without propellant and accessories, versions 1, 2 and 3, respectively, weigh 140 kg, 142 kg and 160 kg, while the acces-

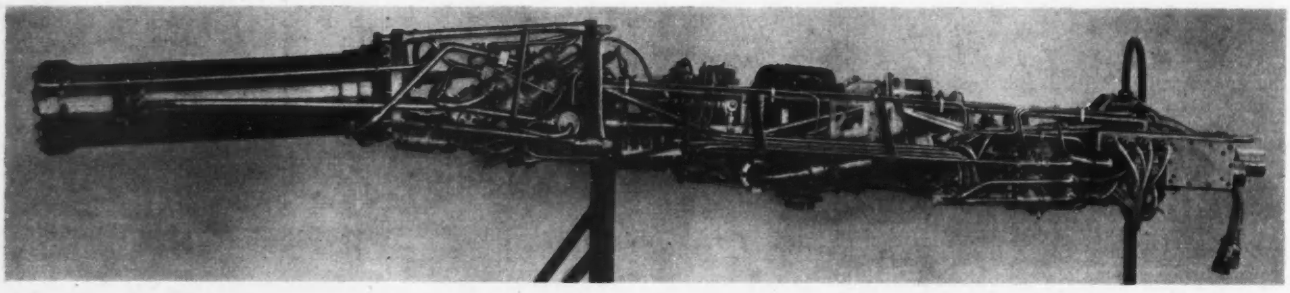


Fig. 2—S.E.P.R.66 rocket motor, as employed in "Mirage I." This motor is made with either one or two combustion chambers. Maximum thrust at 12,000m, is about 3300 kg

TABLE I—*S.E.P.R. Solid Fuel Rockets*

Design	"732"	"5054"	"5056"	"685"
Characteristics at 20 deg. Cent.:				
Thrust, tonnes ...	20	13·5	18	4·25
Duration, secs. ...	4·5	4	3·1	3·75
Impulse, tonnes by seconds	90	54	56	16
Working pressure, atmospheres	60	70	100	95
Specific consumption, kg/tonne-sec.	5·2	5·2	5	4·9
Charge, kg	470	281	281	82
Casing, kg	315	209	216	54
Total weight, kg...	785	490	497	136
Specific weight, kg/tonne-sec.	8·7	9·1	8·9	8·5

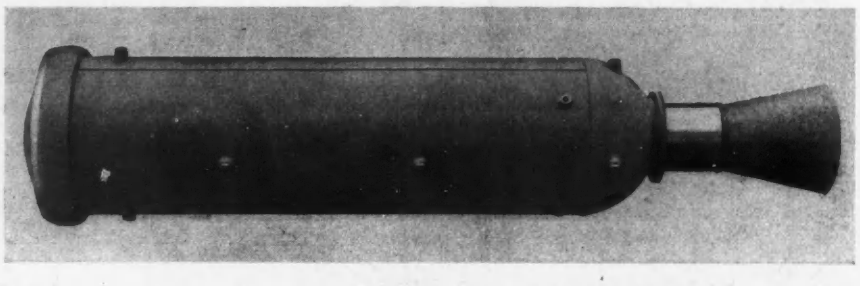


Fig. 3—S.E.P.R.732 solid fuel rocket motor, giving 20 tonnes thrust

TABLE II—*Principal Data of S.E.P.R. Rocket Engines*

Design	"25" and "251"	"65" and derivatives	"481"	"66" and derivatives		
				Version 1	Version 2	Version 3
Application	SO.6025 "Espadon" SO.6026 "Espadon"	SE.212 "Durandal"	SO.9000 "Trident I" (main unit)*	"Mystère IV" M.D.550 "Mirage I"		
Number of combustion chambers	1	1	3	2	1	2
Thrust at sea level, kg	1500	712	1500–4500	750,1500	750–1500 (variable)	1500, 3000
Thrust at 12,000m, kg	1645	825 (8000m)	5200	Sea level thrust + 10 per cent approx.		
Starter	—	—	Electric	Electric	Electric	Electric
Turbine	None	None	Single-stage impulse, 20,000 r.p.m.	—	—	—
Pumps	2 centrifugal : oxidant 50 kg/cm²; fuel 35 kg/cm²	—	2 main, 3 auxiliary centrifugal	—	—	—
Specific consumption at sea level, kg/kg thrust/sec.	0·005		0·0056 (1500 kg) 0·00525 (4500 kg)	Maximum thrust 0·00525 Minimum thrust 0·00555	Maximum thrust 0·00525 Minimum thrust 0·00575	Maximum thrust 0·00520 Minimum thrust 0·00540
Specific consumption at 12,000m, kg/kg thrust/sec.	0·0046	—	0·0048 (4500 kg)	Maximum thrust 0·00480 Minimum thrust 0·00504	Maximum thrust 0·00480 Minimum thrust 0·00490	Maximum thrust 0·00475 Minimum thrust 0·00490
Duration at sea level, secs.	190–200	—	187	—	—	—
Fuel pump drive	Jackshaft from main turbo-jet (Rolls Royce "Nene"), 125 h.p.		Turbine : cooled by water-methanol injection, 20,000 r.p.m.			
Starter	—	—	Electric	Electric	Electric	Electric
Propellant	Nitric acid (specific weight 1·52) ; "Furaline" (specific weight 1·03) ; Mixture ratio 2·4 : 1					
Turbine, length by width by height, mm³	—	—	800×580×900	1524×290×270		
Combustion chamber, length by width by height, mm³	—	—	1785×620×620	724×446×388		
Overall size, length by width by height, mm³	1510×515×435	—	—	2800×600×300		
Weight, without tanks and accessories, kg	86	70	Turbo-pump unit 130 Combustion chamber 100	140	142	160
Weight, with accessories, kg	109	—	—	Approximately 5–8 per cent more		

* The S.O. 9050 "Trident II" is fitted with an S.E.P.R. 631 engine, an improved version of the S.E.P.R. 481, having only two combustion chambers, and giving a maximum sea level static thrust of 3000 kg.

sories add another 5 to 8 per cent. The plant operates on "Furaline" and nitric acid ; it is started electrically and has the same system of turbine cooling as the S.E.P.R.481. Turbine-pump assembly and combustion chamber are preferably mounted together, but can be arranged separately if required.

The solid fuel rockets with colloidal or special charges which the company has developed comprise some auxiliary and take-off rockets with endurances of two to five seconds and a thrust ranging from 1 to 25 tonnes, and impulse of 2 to 100 tonnes-seconds. For main propulsion purposes, endurances vary from six seconds to several tens of seconds, with impulses of 8 to 60 tonnes-seconds. The first group is used in ground-ground, and ground-air missiles, while the second is for ground-air missiles. Work on two-stage air-air missiles is stated to be in progress.

TUBULAR CONSTRUCTION SYSTEM

We have received particulars of the "Mero" system of tubular construction of space frameworks which has found extensive application in Germany, recent examples being the 100m by 50m roof of the "Town of To-morrow" pavilion and other halls at the "Interbau" building exhibition at Berlin (Fig. 1). The system is due to Dr.-Ing. Max Mengering Hausen, Wuerzburg, P.O. Box 455, whose firm produces the components. These are of only two kinds, tubular members and connecting spheres, as shown in our illustration, Fig. 2.

The basic dimension is a distance of 1m between centres of spheres joined by a tubular member. Tubes are made in six lengths to give centre distances of ½m, 1m and 2m, and $\sqrt{2}$ times these values for diagonal connections. Tubes and spheres are made in two weights, for maximum tensile loads of 790 kg and 2360 kg respectively. Compressive loads vary according to the length of the member, from 1320 kg to 413 kg for the light version, and 3280 kg to 1220 kg for the heavy version.

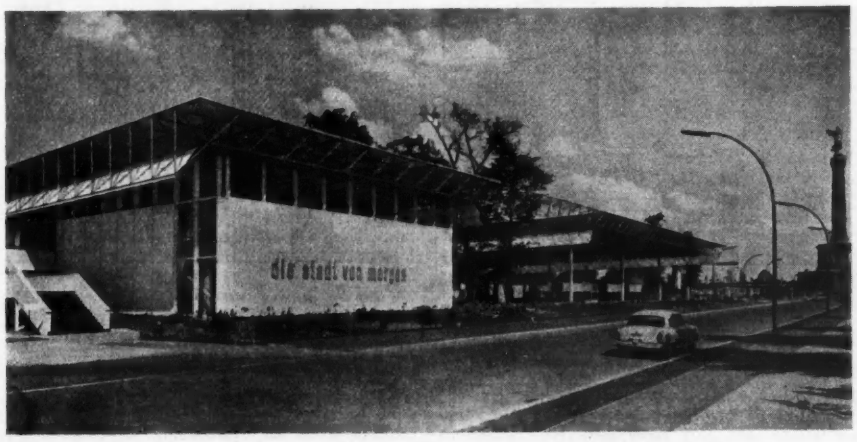


Fig. 1—5000 square metre exhibition pavilion, with flat roof carried out as continuous space framework

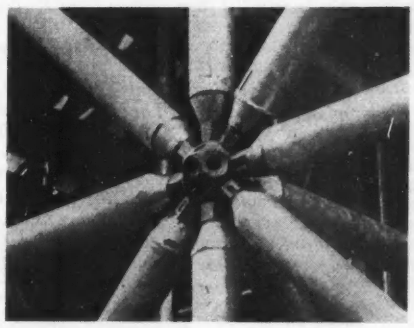


Fig. 2—Joint of tubular structure, showing connecting spheres and tube members

Weights of the 1m nominal members are 1·1 kg and 2·7 kg, and of the spheres 0·25 kg and 1·3 kg respectively. Other members range from 0·6 kg to 4·3 kg (light) and 1·5 kg to 6·8 kg (heavy).

The connecting spheres are drilled and tapped with eighteen radial holes equally spaced (at 45 deg.) along three mutually perpendicular great circles. For the purpose of connecting the tubular members with the spheres, the former are fitted at their ends with rotatable hexagonal sockets with bolts which can slide inside them, the threaded end pointing outwards. A cotter pin passing through the bolt as well as through longitudinal slots in the socket transmits the rotation of the socket to the bolt, and as the thread engages in the sphere, draws it out until the bolt head tightens against a shoulder inside the tubular member.

Manufacture of Metallurgical Coke

A method is reported to have been developed by the Institute of Mineralogy of the Russian Academy of Sciences, for the manufacture of metallurgical coke from inferior grades of coal. Such coal is found in large quantities in the Irkutsk basin in southern Siberia, where iron ore is also present in large amounts. It is the purpose of the new process to help to utilise these coal deposits, and so to make possible the creation of a large iron and steel industry in the region. The method is said to consist in washing the coal and crushing it to 3mm mesh, after which it is heated for some time in electric rotary furnaces. The product is compressed into cylindrical shapes of 60mm diameter by 60mm length, which are subsequently electrically sintered and in this way acquire the necessary strength to be used in blast furnaces. The final product is said to contain about 33 per cent volatile matter and to be 50 to 60 per cent porous ; its crushing strength is claimed to be the same as that of a good metallurgical coke.

National Gas Production at Lacq

Reserves of natural gas at Lacq, in south-west France, are estimated as between 300,000 million and 400,000 million cubic metres. Present production amounts to 1,000,000 cubic metres per day, but it is envisaged to increase this figure to 20,000,000 cubic metres per day by 1961 and 40,000,000 cubic metres per day by 1965. The last-mentioned quantity would represent 7 to 8 per cent of France's total energy requirements. Natural gas from the Lacq deposits contains a large proportion of sulphur, approximately 200 grammes per cubic metre, which is reclaimed before the gas is transmitted to the grid. It is considered likely that France will in this way become in time the second or third largest sulphur producer in the world.

Engineering Test Reactor in Idaho

BY OUR AMERICAN EDITOR

No. II—(*Concluded from page 919, December 20*)

The 175MW Engineering Test Reactor (ETR) of the U.S. Atomic Energy Commission was dedicated in October and is now in operation at the National Reactor Testing Station in Southern Idaho. The average thermal neutron flux of the ETR is 4×10^{14} neutrons per square centimetre per second and its test spaces measure up to 9in by 9in by 36in. These values are believed to constitute the highest neutron flux and the largest test spaces available within any enriched uranium core. The pile is being used for determinations of the effects of intense neutron and gamma-ray bombardment on structural and fuel materials and is expected to play an important part as a research tool in the development of economic nuclear power. The facility is being operated for the A.E.C. by the Phillips Petroleum Company.

IN a high flux reactor such as the ETR, the build-up of xenon produces a large effect on the reactivity of the core. This effect is particularly serious in case a shut-down or scram occurs after the reactor has been operating at high power. In this case, the build-up of xenon is so rapid that a re-start is possible for only a limited time after which the excess reactivity in the core is less than the decrease in the reactivity caused by the xenon build-up. The effect of the xenon build-up after a shut-down in both the initial start-up core, containing aluminium filler pieces in the experimental facilities, and the core with certain experiments in place, was computed by means of perturbation techniques. These calculations were performed using the two-dimensional UNIVAC fluxes and adjoint fluxes. Fig. 4 shows the time available for a re-start of the ETR after a scram as a function of time during the running cycle. It can be seen that at the start of the cycle, one has approximately twenty-six minutes in which

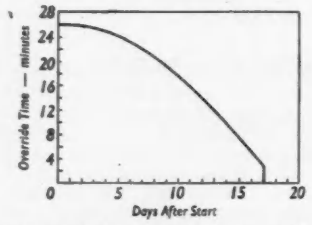


Fig. 4—Plot of time available to over-ride xenon after scram, assuming four minutes to be required to reach full power after start

to re-start, whereas, after seventeen days of operation, a re-start is not possible once the reactor has scrammed. It should be mentioned that the curve of Fig. 4 is based upon a ganged rod withdrawal rate of 16in per minute. (The black and grey rods are withdrawn successively.) In order to obtain the maximum time available for a re-start after a scram the control rod speed was made as fast as was consistent with safety considerations. In order to provide increased safety during reactor start-up, the scram level is set at one-tenth full power. There is incorporated into the electronic control circuit a provision which automatically changes the scram level from one-tenth of full power to one and a half times full power if the period at the one-tenth power level is above a preset amount. In the event of a start-up accident, where the reactor was inadvertently placed on a short period and the period scram did not function, the reactor would scram at the one-tenth power level. A considerable overshoot of this level can be tolerated.

Use of Burnable Poisons

In order to reduce the control requirements and still maintain an operating cycle of approximately twenty days without using black rods for operating control, the ETR incorporates a burnable poison on its fuel elements. The operation of the burnable poison is simple in concept. At the start of the operating cycle, the boron in the core is a parasitic absorber which decreases reactivity. As the reactor operates, fuel is depleted, but so is boron. The boron concentration can be adjusted so that the boron burns at such a rate that the reactivity excursion, due to fuel burn-up, is greatly reduced. One has a considerable amount of freedom in setting the fuel and boron loadings, and can, in fact, cause an initial increase in reactivity if enough boron is placed in the fuel element so that the burn-up of boron over-compensates for the burn-up of fuel. In the case of the ETR, the boron concentration for the initial start-up core was set at the minimum amount required in order to achieve a twenty-day running cycle using the twelve grey rods. A longer running cycle could be achieved by increasing the boron, but one must pay for this by increasing the initial fuel loading, and, thereby, decreasing the flux level in the reactor at the start of the cycle.

Initial studies of the use of burnable poison and the change in reactivity with time were conducted using the one-dimensional model. These calculations were performed by dividing the core into a number of annular regions and approximating the operation of the ETR for five-day intervals. At the end of each five-day interval, the cross sections in each of the annular regions were changed to account for the burn-up during the five-day interval. The calculation was then repeated under the assumption of another five-day operation. Although these calculations provided a considerable insight into the use of burnable poisons, a comparison to the UNIVAC calculations indicated that the approximation of the core as a uniform cylinder was not adequate for this purpose. However, as indicated in Fig. 6, which shows the thermal flux distribution as a function of time obtained in a one-dimensional calculation, the thermal flux distribution remains very constant in shape, although its magnitude changes considerably. In calculating burn-up effects for the two-dimensional studies, the assumption was made that the shape, but not the magnitude, of the thermal flux did not alter radically during the ETR operating cycle. The use of the grey rods, which do not appreciably distort the flux, should make such an assumption reasonable. Under this assumption, it was possible to calculate burn-up in three dimensions by performing perturbation calculations based on the UNIVAC data. In performing three-dimensional calculations, the vertical distribution was taken from a one-dimensional calculation assuming a uniform core. It was assumed that the vertical and horizontal distributions were separable. Using these perturbation techniques, it was possible to adjust the fuel and poison loading to obtain the desired running cycle.

When materials are placed in the core of the ETR they will be heated due to gamma-ray absorption. Because of the high power density in the ETR, gamma heating is high, a factor which must be taken into account in the design of high-pressure loops, where the problem of thermal stress is severe. Gamma heating was calculated in the core with experiments under the assumption that the gamma energy absorbed at a point is equal to the average gamma energy produced in a region within one mean free path of the point. Since the predominant source of heating in the core is due to gamma-rays of under 2 MeV a circle was drawn about the point in question of radius equal to the mean free path of a 1 MeV gamma-ray. The gamma heating at this point was taken to be the average gamma production within the circle. The calculations have shown that the gamma heating is quite high, approaching 40W per gramme at the inner corner of the 9in by 9in experiment.

Reactor Pressure Vessel

The ETR pressure vessel was designed to contain a fuel element and control system,

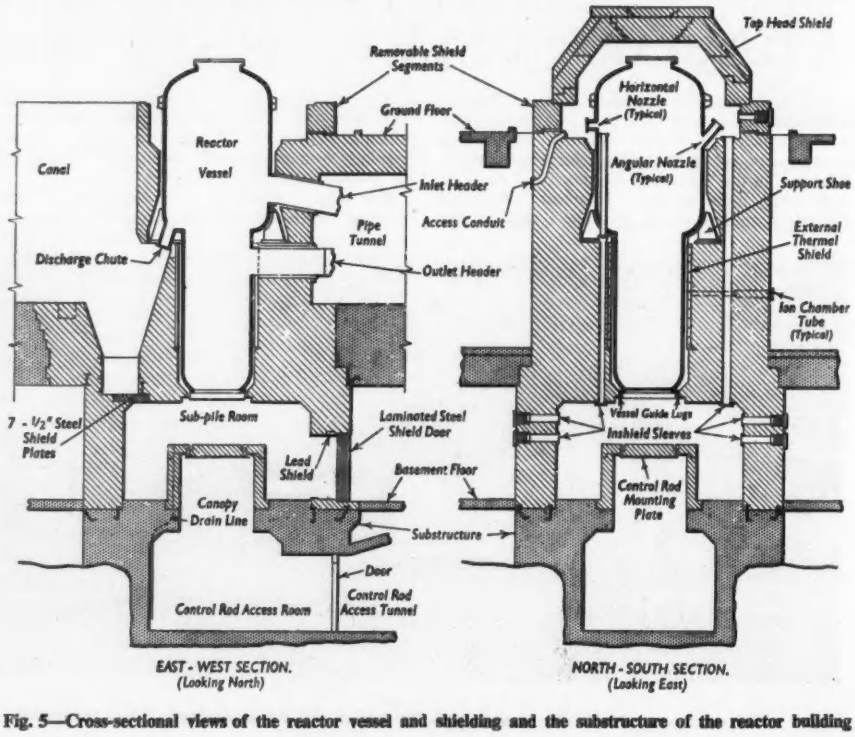


Fig. 5—Cross-sectional views of the reactor vessel and shielding and the substructure of the reactor building

experimental components, internal thermal shields and cooling water at 250 lb per square inch gauge and 200 deg. Fah. The shielding requirements were set by the configuration facilities adjacent to the vessel, i.e. the tunnel for containing coolant piping, accessibility to the top of the reactor for servicing and experimental connections, the proximity of the canal for moving and storing fuel elements and other

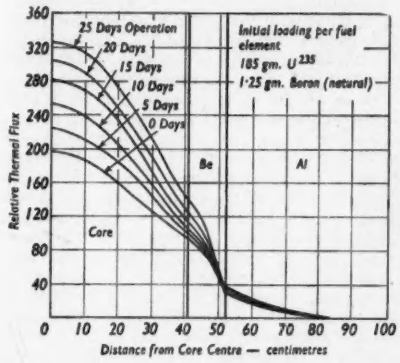


Fig. 6—Thermal flux distribution in the ETR as a function of time

irradiated material under water, the control rod drive mounting, access to the control rod drives, and access to the underside of the vessel for taking experimental loops out to cubicles which are shielded from the space under the vessel. A cross section of the reactor vessel and shielding is reproduced in Fig. 5. In the East-West section the working canal can be seen to the left and the pipe tunnel to the right. The top head shield is not shown in the left-hand view. The control rod mounting plate is shown in the sub-pile room and the control rod access room is the lowest space in the reactor substructure.

The ETR construction programme posed a few special problems for the designers of both the vessel and shielding. For example, the designers were governed by the sequence of construction. They had some control over which items would be built first, since the first objective was to bring the reactor building to grade level and to start erecting structural steel. Furthermore, the operators of the reactor had certain requirements which were basic to some elements of the design. The parameters governing shielding requirements for nuclear radiation involved the sources of radiation, the cooling effect of the various shields and the geometry of the radiating source and of the shield to be built.

The pressure vessel is of carbon steel, clad on the interior with Type 304L stainless steel. The vessel has two transitions from large to small diameters. The areas of transition represent regions of stress concentration. Nozzles, pipe penetrations and connections of internals to the vessel walls also gave special problems in stress concentration. The bottom head stresses were particularly difficult to analyse since the head carries water, internal pressure and control rod loads, and is subject to control rod shock loads. Since this head is a flat plate full of holes for rod sleeves and experimental facilities, the holes are all sealed against leaking with a special packing arrangement.

The vessel was built to rather close tolerances to ensure the proper fit of such internal components as the grid plate illustrated in Fig. 9. Inspection and testing were more stringent than for most pressure vessels; these included ultrasonic testing of all materials, 100 per cent radiographic inspection, dye testing and magnetic-particle testing of all forgings and welds. The type of transition preferred varied among the various fabricators who bid on the fabrication. Some preferred a conical transition piece, but the successful bidder preferred an ellipsoidal shape which was the shape used on the ETR vessel. Vertical load is carried by a series of support points at the vessel transition midway between the coolant water headers. This support consists of a series of flat plates fastened to the vessel and sliding on flat plates resting on a bed plate anchored to the concrete. Studs in slotted holes keep the vessel from rotating or moving laterally. Expansion is confined to radial movement and movement along the axis of the vessel each way from the support point.

One early scheme for supporting the vessel included steel columns run up from approximately the basement floor level and carrying the vessel with either a girder system or hanger rods. This scheme was considered in case it became necessary to install the pressure vessel before the shielding concrete could be brought to the level of the vessel transition. It was abandoned because uneven heating of the steel could cause misalignments, because it was too costly and, finally, because the shield concrete was carried to the necessary height before the vessel arrived at the site. Fig. 7 shows the erection of the

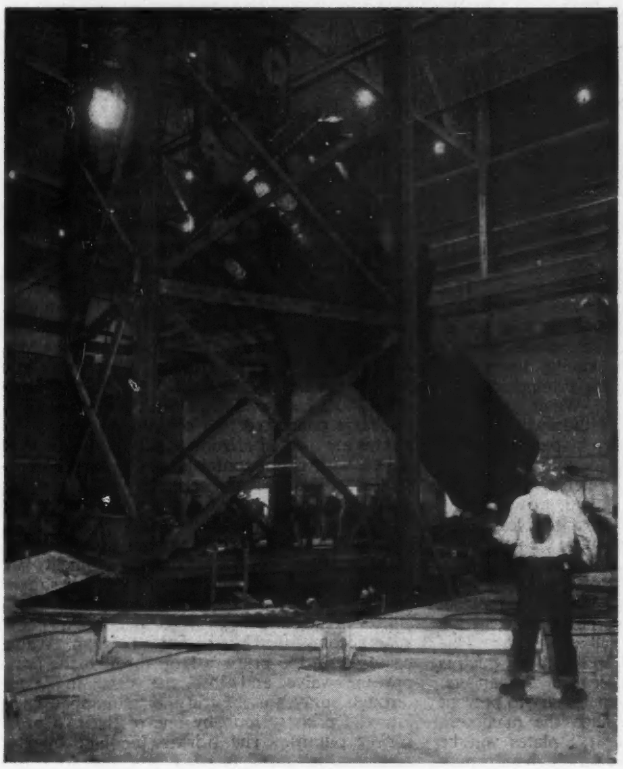


Fig. 7—Erection of the 75-ton reactor pressure vessel, using a four-legged gallows frame

vessel within the ETR building. The support assembly was field-welded to the vessel after it was accurately placed in its final position, thus eliminating costly fabrication tolerances in the support system. For installation purposes, a four-legged gallows frame was erected over the vessel foundation. The vessel was skidded into a horizontal position beneath the gallows frame, rotated 90 deg. and lifted into a vertical position over its foundation by means of two twelve-part sets of block and tackle. Hoisting was accomplished with a 200-ton diesel skid hoist.

Thermal Shielding

The thermal shielding consists of: (*a*) four concentric cylinders of Type 304 stainless steel around the core and inside the vessel; (*b*) the vessel wall, and (*c*) an external steel-plated and lead-filled shield cooled by water in stainless steel tubing. These shields reduce the incident radiation on the concrete biological shield to a relatively low amount, and the circulating water, both in the vessel and in the external thermal shield, removes most of the heat. In the design of the ETR there were several possible choices for shielding material: conventional concrete, concrete made with barytes, magnetite, ferro-phosphorus or other dense materials as an aggregate. The economics at Idaho Falls indicated that magnetite was the preferred aggregate for the ETR. Magnetite concrete, with a density one-and-a-half times that of conventional concrete, gave a thinner shield than conventional concrete but a slightly thicker one than would have been the case with some of the other aggregates. The biological shield is a thick-shelled cylinder with 8ft thick walls, notched at the canal, with the 3ft thick console floor, the canal walls and the pipe tunnel walls framed into it. The entire shield is clad both inside and outside with a ¾in steel plate which serves as a concrete form and a surface on which to weld experimental equipment brackets and the ends of pipe sleeve penetrations.

The sub-pile room walls are of magnetite concrete and are 4ft thick. Entrance is through a laminated steel door; this method of construction was used to permit possible future dismantling. The door is 18in thick and weighs 15 tons. The control rod mounting plate and its supporting walls shield the control rod access room from the sub-pile room. The mounting plate has a steel shell and is filled with high-density concrete. The walls below the plate are 1ft thick magnetite concrete. The top head shielding consists of circular discs or washers and flat circular plates. This assembly rests on block segments arranged in a circle, the segments resting in turn on the solid concrete shield. These units are split up in this way to reduce each piece to a weight which can be picked up by the 30-ton overhead crane. They also support the handling equipment and are designed to span the top of the vessel without resting on it. These segments are all of magnetite concrete with steel corner and partial surface protection and with lifting hooks or rings for attachment of removal slings. The block segments are provided with sleeves for the entry of experimental loops. This shield was originally conceived as a cast steel item but would have cost more than a concrete shield and the castings would have been larger than most shops could handle.

The canal shielding consists of a thick bottom, and side walls 6ft and 7ft thick at the base which taper to a thinner section at the top where the intensity of radiation is reduced. The entire canal construction is of conventional concrete. It spans between piers which rest on lava bedrock and it, in turn, supports the ground and console floors of the building. The 36in primary coolant headers are contained in a tunnel of magnetite concrete. The tunnel has walls and ceiling 4ft thick with a thick floor of part magnetite and part conventional concrete. It supports the console and ground floors of the reactor building and is in effect a deep box girder spanning about 50ft.

Cooling System

The design of the ETR cooling system was based on the requirements of: (*a*) removal of approximately 175MW of heat from the reactor core and the dissipation of this heat to the atmosphere; and (*b*) maintenance of the required flow, pressure, temperature and water purity in the primary coolant system to provide adequate core heat transfer at all times, and to prevent excessive corrosion and radioactivation. The design of this reactor was based upon carrying the core heat transfer rate to the maximum safe limit in order to obtain the highest possible neutron flux. Because of this high heat transfer rate in the ETR core, special care had to be exercised in the

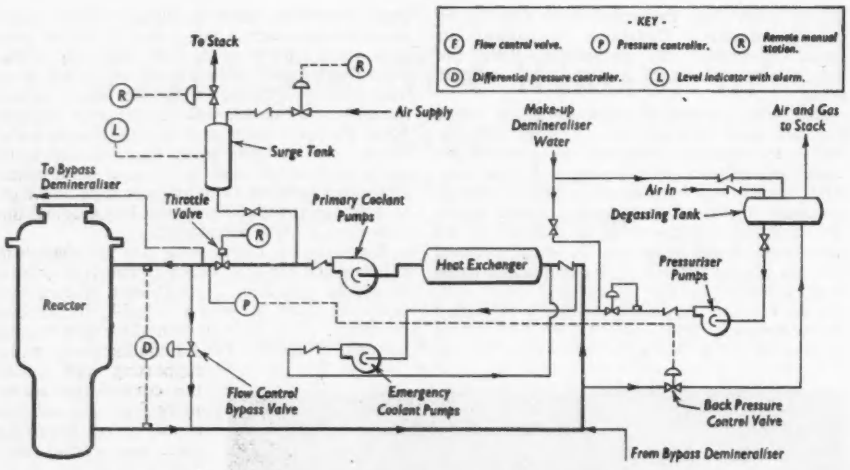


Fig. 8—Simplified flow diagram of reactor primary coolant system

design of the primary coolant system so that the core would be adequately protected not only during normal operation, but also during emergency operation.

The coolant system for the ETR is of the double loop type. Demineralised water in the primary loop passes through the reactor and the tube side of shell-and-tube heat exchangers. This system incorporates emergency cooling capacity, by-pass demineralisation and de-gassing equipment. The secondary loop rejects the heat to the atmosphere through a cooling tower. A simplified flow diagram of the primary coolant system is shown in Fig. 8. Water purity of ½ p.p.m. is maintained by withdrawing a side-stream and sending it through a by-pass demineraliser. The system is pressurised to 200 lb per square inch absolute at the inlet of the reactor vessel and, with an approximate pressure drop of 50 lb per square inch across the vessel, the outlet pressure is 150 lb per square inch absolute. The reactor inlet temperature is held at 110 deg. Fah. by controlling the flow of secondary water through the heat exchangers. Total flow through the reactor is 44,000 gallons per minute, giving an outlet temperature of 138 deg. Fah. This flow is provided by four pumps, each of which is connected to a bank of three heat exchangers. Pressurising of the system is necessary to prevent any boiling in the core, since the maximum surface temperature of the fuel plates will be 280 deg. Fah. Because of the very high maximum heat flux, it was considered necessary to prevent boiling in the core at any time in order to prevent any possible burn-out of the fuel plates.

There are four banks of three heat exchangers, each in parallel, each bank being stacked in a vertical plane. The exchangers use a shell-and-tube counter-flow arrangement, with the primary water flowing through the tubes. The units have fixed double-tube sheets and are of straight-through, single-path design. All parts in contact with primary water are constructed from Type 304 stainless steel. The space between the double tube sheets is connected to a drain, thus preventing any leakage from the primary to the secondary side at the ends of the tubes. There are four primary pumps, with each pump suction connected to a heat exchanger bank and each pump discharge connected to a common header. The pumps are of the horizontal split-case centrifugal design with a horizontal discharge and bottom suction. The primary coolant piping, ranging up to 36in diameter for the two headers, is fabricated of Type 304L stainless steel with welded construction. The piping as well as the other primary coolant system equipment has been designed for a pressure of 250 lb per square inch gauge.

Pressurising and degassing of the primary coolant is accomplished by a combined system. Water passes from the primary loop through the back pressure valve and into the degassing tank through spray nozzles and then is pumped back into the primary loop by one of the two pressuriser pumps. The primary coolant by-pass demineraliser consists of a bank of four ion exchange columns, each containing 30 cubic feet of resin, of which one is an anion bed, one a cation bed, and two are mixed beds. The by-pass water is withdrawn from the inlet header and returned to the outlet header after demineralisation using the reactor pressure drop to furnish the by-pass flow and thus eliminating the need for a pump in the system. Piping is arranged so that the pH value of the water in the system can be controlled by varying the flow to the different columns of the by-pass demineraliser. Pressurising the primary coolant system is accomplished by continuously pumping 300 gallons of water per minute into this system and withdrawing water at the required rate to maintain and control the primary coolant pressure. The pressuriser pump takes water out of the degassing tank and pumps it into the system through a flow control valve set for 300 gallons per minute. The back-pressure valve, controlled by a pressure controller situated in the reactor inlet line, discharges 300 gallons per minute under steady-state operation. If, for some reason, the pressure in the system starts to fall, the back-pressure valve will start to close, thereby reducing the outward flow and raising the system pressure back to the desired point. The 120 cubic feet pressure-surge tank, filled with air to two-thirds of its volume, serves as a cushion on the system during normal operation, so that the pressure is easier to control within a small range. The main justification for this tank, however, is its function during emergency operation when it furnishes reserve pressure capacity. The water level in this tank is set at start by use of the air bleed valves. Only minor adjustments of the water level in this tank are necessary during normal operation. Internally pressurised seals are employed on the primary pumps and on various other penetrations, including many of those through the reactor vessel bottom head. This type of seal employs demineralised water at a higher pressure than that of the system and thus any leakage through the seal is inward. The pump which pressurises this water is on the emergency power supply when normal power fails, so that this pressurisation is continued even after a power failure.

The by-pass flow through the demineraliser is controlled by an automatic flow control valve in the inlet line to the demineraliser. The valve receives a signal from a flow meter through a recorder-controller having an adjustable setting. During reactor shut-down, up to 300 gallons per minute can be passed through the by-pass demineraliser by the pressuriser pump if the water becomes too radioactive to remove the cover of the reactor, or to be discharged to the retention basin. During that time, primary water is recirculated in the primary loop at a rate of 2000 gallons per minute by an emergency and shut-down pump.

The system is designed for non-regenerative operation, but the tanks are provided with stubs for future addition of a regeneration system.

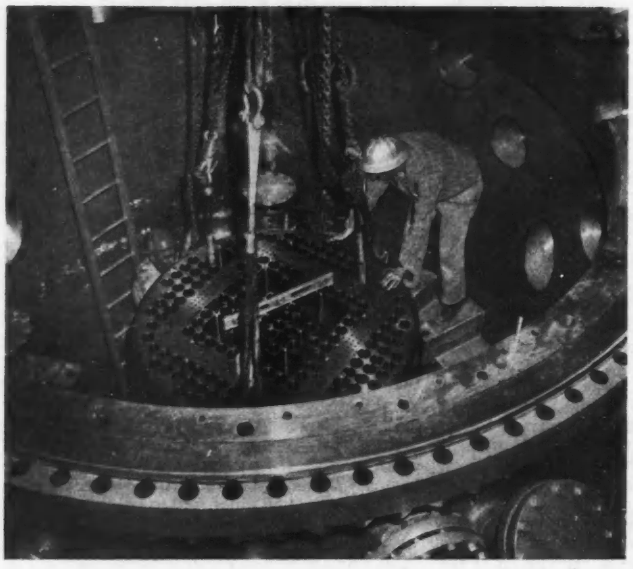


Fig. 9—Installation of grid plate within the reactor pressure vessel for the support of core assemblies and reflector pieces

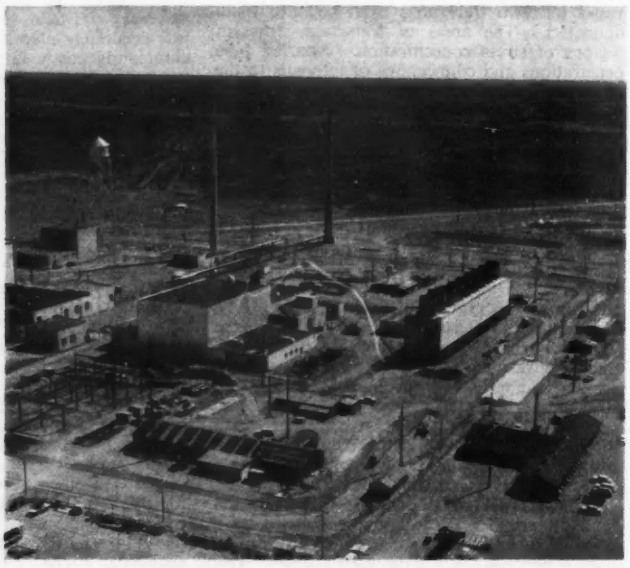


Fig. 10—Aerial view of the Engineering Test Reactor buildings at the National Reactor Testing Station in Idaho

Spent resin is slurried into a disposable casket. The fresh supply of resin is fed into the tanks with demineralised water. This water is drained to the warm sump tank or retention basin. The pH of the primary coolant is controlled by by-passing part of the fluid around the anion or cation tanks and the mixed bed tanks. Designed for flexibility, each tank in the system may be completely or partially by-passed, the fluid proportioned between the tanks, or diverted completely through one tank. This is accomplished by diaphragm-operated control valves situated on the pipe leading to each tank inlet which are controlled by remote manual stations mounted on the process water control panel. Flow indicators for each tank are also situated on the panel adjacent to the manual control stations.

The radioactivity in the primary coolant water under normal conditions is primarily short-lived N^{16} and radioactivated water impurities and corrosion products. Although it has a half-life of only seven seconds, N^{16} does emit a very strong gamma, and this sets the amount of shielding required for the primary coolant system. In addition to the gross gamma monitor in the system, there is a fission-product monitor consisting of a small cation column and a small anion column with a gamma detector on it. This device detects fission products in the water if a fuel element fission break occurs. Gross gamma monitors are also used in the secondary coolant system. Attached to the outlet lines from each heat exchanger bank, they detect any primary-to-secondary-system leakage in the heat exchangers by detecting radioactivity in the secondary water.

The secondary coolant system is designed to remove reactor heat from the primary coolant water in the heat exchangers. The secondary coolant water is, in turn, passed over a set of cooling towers, where the temperature is reduced to within a few degrees of wet bulb temperature by evaporation. From the cooling tower cold well, secondary water is pumped by vertical turbine pumps to the shell side of the primary heat exchangers, thus completing the secondary coolant loop. The secondary coolant is also used to remove heat from the experimental facilities. The secondary loop contains 632,000 gallons of water, including stored water in the cooling tower basin. The quantity of water lost by evaporation or wind drift averages 3 per cent of the total flow of 43,000 gallons per minute, or approximately 1500 gallons per minute. Make-up raw water is supplied from deep-well turbine pumps, and hexa-meta phosphate and dichromate are added to this raw water as inhibitors. In addition, the pH value is controlled automatically between 6·3 and 6·7 by sulphuric acid addition. Chlorine is added to control slime and algæ to prevent fouling of the primary heat exchangers. This chemical equipment is situated in the cooling tower pump house and the chemicals are injected into the raw water downcomer, immediately prior to entering the pump house clear well. In order to maintain the reactor inlet cooling water temperature approximately constant and to take care of changes in cooling water requirements resulting from changes in experiments, a flow control valve is provided in the secondary loop in the main pump discharge header in the cooling tower pump house. The four secondary coolant pumps are situated in the pump house adjacent to the cooling tower. They are two-stage, vertical turbine pumps, each with a capacity of 9550 gallons per minute.

The cooling tower is a counterflow induced draught unit, fabricated largely from redwood and partially covered by corrugated asbestos cement. The tower is made up of nine cells designed to handle the total of 43,000 gallons per minute of 110 deg. Fah. water with a final temperature of 78 deg. Fah. The temperature control system which controls the primary coolant reactor inlet temperature at 110 deg. Fah. consists of a temperature sensing element in the primary coolant supply header, which, through a recorder-controller, operates the 30in butterfly valve in the main secondary coolant lines. This valve controls the flow of secondary coolant to the heat exchangers and thus controls the primary coolant reactor inlet temperature.

Grid Plate Fabrication

One of the major material problems encountered in the ETR programme was that of procuring an adequate grid plate forging. This item is a large forged disc of Type 347 stainless steel, 9in thick by 65in in diameter, weighing approximately 9000 lb. Type 347 analysis was chosen for this application by reasons of its slightly higher allowable working stress compared to Type 304 material. In the finished condition, this plate is perforated with approximately 800 holes and weighs over 6000 lb. In service, the grid plate supports and establishes the spacing of the fuel element assemblies. Fig. 9 shows a view of the grid plate installed within the reactor. The combined load imposed by the fuel elements and appurtenances, together with the force of the coolant, is calculated to be approximately 200,000 lb.

An indication of the difficulty in procuring this item is pointed out by the fact that out of fourteen suppliers invited to bid, only two firms submitted bids. The firm selected forged two grid plate discs from the same ingot, which was a 45,000 lb octagonal ingot, top poured and sand hot topped. Each disc was flattened and the corners bumped down to form a rough plate. Subsequent ultrasonic examination showed both of these discs to be defective in and around the central area. Since the supplier would not accept ultrasonic indications as a basis for rejection, each disc was drilled through the defective areas and was found to have a large burst the size of a man's fist. On this basis the supplier accepted the rejection. It was then decided to make two more discs. The technique this time was to pour another 45,000 lb ingot, select a larger section from the bottom and flatten this, working it out to a roughly square, flat plate, 70in by 70in by 9½in thick, and then powder-cut the disc from this plank. The principal forging difference on this disc was the elimination of the bumping down of the corners. The ultrasonic examination revealed a minor residual ingot centre-line condition. However, by orientation of the final machining layout, the defects could be aligned along a neutral axis and this grid plate was considered to be adequate for the intended service. The second disc of this group was produced by the same corner-bumping technique used for the initial two, as this was the only way to obtain a disc of suitable size from the smaller portion of the ingot. When this disc showed the same centre forging burst as the first two, it was confirmed that corner bumping was the particular forging operation causing the defect. This particular problem, it could be said, pointed out the definite advantages of ultrasonic inspection.

The machining of the grid plate was an extremely tedious and complex operation since over 680 penetrations of varying size and shape were involved with permissible tolerances varying from 0·001in to 0·005in. The original delivery schedule was twenty-five weeks after receipt of forging. Delays encountered in the later phases of machining extended the delivery by approximately two months, even though for most of the period machining was performed on the basis of a 154-hour work week.

Building Construction

The ETR project occupies an area of 8 acres. As shown in Fig. 10, the principal facilities consist of five adjoining buildings covering a total area of 45,000 square feet, a separate pump house and a cooling tower. The reactor building is shown in Fig. 11. Building construction below grade is reinforced concrete and above grade consists of a structural steel frame covered with insulated metal-sandwich siding and an insulated steel deck with a built-up roof. The building is airtight for safety. The console floor is situated between the grade level ground floor and the basement 30ft below grade. The floor thickness varies from 3ft to 5ft and serves both as a radiation shield and a working surface for reactor experiments. The structure includes a reinforced concrete, T-shaped, radioactive material storage canal, approximately 35ft by 60ft by 20ft deep, constructed between the ground floor and the console floor. The reactor vessel is installed in the centre of the building, and the circular foundation for the vessel extends into lava bedrock approximately 15ft below the basement floor. Its 5ft thick walls, extending to the ground floor level, form the sub-pile room and control rod access room below the reactor.

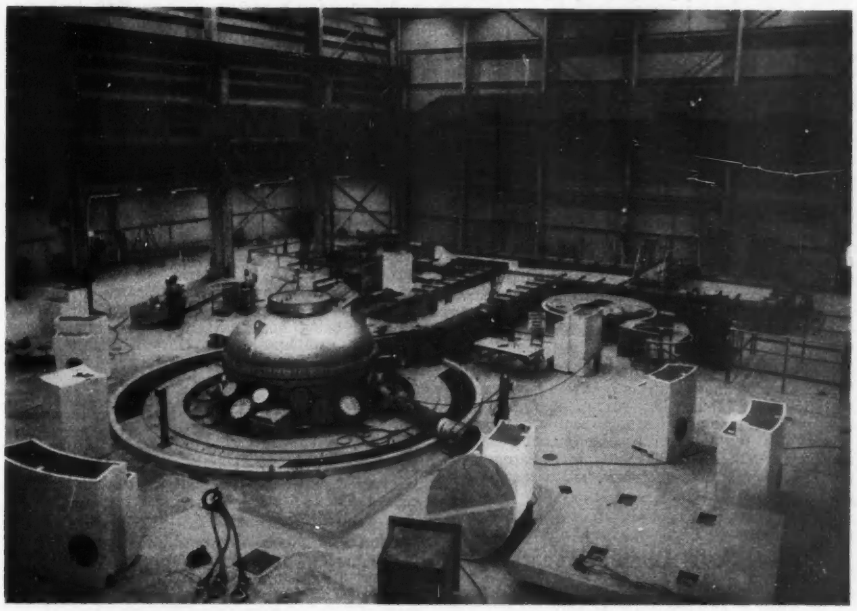


Fig. 11—Interior view of the reactor building with the concrete shielding blocks removed from the reactor top and T-shaped canal in background

The compressor building adjoins the reactor building. Access to the reactor building is through an airtight man door in a common wall. The siding and roofing are similar to that of the reactor building except that airtightness is not required. The heat exchanger building adjoins the compressor building and the reactor building. A two-storey office building adjoining the reactor building includes the reactor operating console and instrumentation, the reactor building heating and ventilating equipment, as well as office space. Finally, an electrical building of steel frame, one-storey construction, adjacent to the reactor building, includes high and low-voltage switchgear and control panels for the ETR, emergency power battery rooms and a 1200kW diesel-electric generator.

Personal and Business

Appointments

MR. N. C. LAKE has been appointed deputy managing director of Head Wrightson and Co., Ltd.

MR. W. D'ARCY MADDEN, M.I.E.E., M.I.Mech.E., has been appointed deputy chairman of Foster Yates and Thom, Ltd.

MR. H. GAYDON, deputy managing director, has been appointed joint managing director of Hills (West Bromwich), Ltd.

MR. J. R. GREENWOOD, JNR., general works manager, has been appointed a director of Craven Brothers (Manchester), Ltd.

THE NATIONAL INSPECTION COUNCIL FOR ELECTRICAL INSTALLATION CONTRACTING has appointed Mr. P. G. Wallis as assistant technical officer.

THE NATIONAL COAL BOARD has announced that Mr. K. L. Stretch has been appointed director of its central engineering establishment, Bretby, South Derbyshire.

MR. W. H. CARTWRIGHT, general manager of Stern and Bell, Ltd., a member of the engineering division of the Triplex safety-glass group of companies, has been appointed a director of the company.

HEAD WRIGHTSON EXPORT COMPANY, Ltd., has announced that Mr. Anthony Neville will join the company on January 1 as manager, Europe; and Mr. Douglas Dodds-Parker, M.P., has been appointed a director.

MR. D. R. G. DAVIES has been appointed technical services superintendent, with effect from January 1, at the Workington Iron and Steel Company, in succession to Mr. H. B. Lloyd. Mr. L. Jackson will succeed Mr. Davies as chief chemist.

THE BOARD OF TRADE has announced the appointment of Mr. Kenneth McGregor as the United Kingdom senior trade commissioner and economic adviser to the High Commissioner in Canada, in succession to Mr. Gordon Bowen, who will return to the headquarters of the Board on completion of his tour of duty.

RANSOMES AND MARLES BEARING COMPANY, Ltd., has announced changes in its north-west area representation from January 1. Mr. A. P. Gibbs, area manager, will take up an appointment at head office. Mr. H. V. Willder will become manager of the Manchester office, assisted by Mr. E. L. Paton. Mr. G. H. Walker, stores supervisor, will become Liverpool sub-office manager.

Business Announcements

CATTON AND CO., Ltd., Yorkshire Steel Foundry, 29, Chadwick Street, Leeds, 10, has changed its telephone number to Leeds 36011.

THE BRITISH TRANSPORT COMMISSION has announced that Mr. C. S. Lock, press officer, is to retire at the end of December, after thirty-six years' service.

STANLEY WORKS (G.B.), Ltd., Rutland Road, Sheffield, 3, states that it has taken over responsibility for servicing Stanley electric tools made in the United States.

THE WAYNE TANK AND PUMP COMPANY, Ltd., states that it is now resident in its new premises at Western Road, Bracknell, Berks (telephone, Bracknell 1600-9).

FISHER AND LUDLOW, Ltd., has announced the opening on January 1 of its new Scottish office at Fisholow House, Fife Crescent, Bothwell, Glasgow. Mr. F. P. Whiteley will be in charge of the new office.

RUSTON AND HORNSBY, Ltd., Lincoln, and J. L. KIER and CO., LTD., London, have agreed to work in close technical collaboration on the design, development and building of nuclear power stations of 5MW to 25MW electrical generating capacity. A combined team is being established for this purpose at the Lincoln works of Ruston and Hornsby, Ltd.

BENNIS COMBUSTION, Ltd., states that following the acquisition of a controlling interest in the company by James Hodgkinson (Salford), Ltd., Mr. G. M. Mellor has relinquished the appointment of joint managing director of Bennis Combustion, Ltd., in order to concentrate on the sales activities of the company. He will continue to serve as chairman. Mr. B. W. Dawkins has been appointed a joint managing director of Bennis Combustion, Ltd., and the board of the company is now constituted as follows: Mr. G. M. Mellor, chairman; Mr. F. Howarth and Mr. B. W. Dawkins, joint managing directors; Mr. R. B. Page, Mr. J. S. A. Hodge, Mr. N. C. Crighton and Mr. E. L. Hollinshead, directors.

Miscellanea

INTERNATIONAL COMBUSTION ENGINE CONGRESS.—The British National Committee states that the fifth International Congress on Combustion Engines will be held in Germany in the second quarter of 1959, and that the theme will be "Diesel Engines and Gas Turbines up to 1500 h.p.—Current Problems Concerning Design, Production, Development and Running at Site."

RUST PREVENTING METAL COATING.—A rust preventing metal coating, introduced by Corrosion Ltd, 16, Gloucester Place, London, W.1., is specially designed for the protection of steel chimney stacks, furnace doors and other steelwork subjected to high operational temperatures. It is supplied in liquid form ready for application by normal paint techniques, and does not need the addition of any hardener, accelerator or curing agent. It is stated that "Glostack" coating will stand up to temperatures well over 800 deg. Fah. for long periods, and is stable and unharmed by a wide range of temperatures from normal atmospheric temperatures to the upper limit quoted.

ALUMINIUM CRANE JIBS.—Three 116ft long aluminium crane jibs have been supplied by Head Wrightson Aluminium, Ltd., a subsidiary of Head Wrightson and Co., Ltd., to Wm. Cory and Son, Ltd., for fitting to 8-ton level luffing grabbing cranes at the Erith depot. These cranes are used for discharging coal into coastwise colliers from ocean-going ships, and the aluminium jibs, without fittings, weigh 7 tons each, whereas their counterpart in steel would be at least 12 tons. The jibs have been designed to lift a nominal load of 8 tons at all radii between 23ft 6in (minimum) to 96ft 3in (maximum), hoisting this tonnage at 300ft per minute, slewing at 1½ r.p.m., and luffing at 150ft per minute.

DIRECTOR FOR HIGH ENERGY LABORATORY, HARWELL.—Dr. T. G. Pickavance has been appointed by the National Institute for Research in Nuclear Science to direct its high energy laboratory. The latter is being built next to the Atomic Energy Research Establishment at Harwell, and is to be known as the Rutherford High Energy Laboratory. It will house the Institute's first large accelerator, the magnet ring of which is to be 120ft in diameter and 6000 tons in weight. Dr. Pickavance at present heads the group in the U.K.A.E.A. responsible for the new accelerator, and will continue in this work. He has been employed at Harwell since 1946, and has been deputy head of the General Physics Division since 1955.

GARSTON DOCKS.—The British Transport Commission has approved an expenditure of over £500,000 for the modernisation of the North and Old docks at the port of Garston, on the right bank of the River Mersey. The improvements will include the replacement of hydraulic quay cranes by eleven electric level-luffing cranes of greater lifting capacity and outreach—six for the North Dock and five for the Old Dock; the renewal of the crane tracks on a standard gauge of 15ft, and the repaving of quays with concrete in which new railway lines will be laid flush with the surface. This modernisation scheme for the North and Old docks brings the total estimated cost of work, either in progress or authorised, at Garston Docks to over £1,250,000.

I.C. ENGINE TESTING SET.—We are informed by Newage (Manchester), Ltd., 6, Carlos Place, Grosvenor Square, London, W.1, that two of its internal combustion engine testing sets have recently been installed in the Verdin Technical College and School of Art, Cheshire, and the Denbighshire Technical College, Wrexham. The equipment is stated to have been designed especially for use in technical colleges, and consists of an engine, dynamometer, indicator, air tank and fuel consumption meter in an assembly mounted on a single base plate. From the tests that can be performed with the apparatus, students may calculate efficiency under varying load, heat balance, torque, and fuel consumption. The prime mover can be chosen from the range offered by the British Motor Corporation, the usual selection being the 1500 c.c. petrol engine. A Heenan and Froude hydraulic dynamometer is driven normally by cardan shaft; a flexible coupling is used when space is limited. A Dobbie McInnes "Farnboro" indicator is installed, but alternatives may be supplied. Air flow is read directly on a Kent curved-tube manometer, though a U-tube can be provided instead: inlet air going through the measuring orifice passes into an air box to damp pulsations. An Amal flow meter measures petrol consumption, and a glass cylinder with ½ and ¼ pint markings can be used with a stop watch to measure diesel consumption. Petrol engines can be fitted with apparatus for the Morse test. Normal engine instruments and controls are provided.

Launches and Trial Trips

S.N.A.5, cargo ship; built by the Ateliers et Chantiers de Provence for the Société Nationale d'Affrètement; length overall 380ft 9in, length between perpendiculars 361ft 11in, breadth moulded 51ft 6in, depth to main deck 25ft 5in, draught loaded 21ft 4in, deadweight 5700 tons, gross tonnage 3800, hold capacity 438,000 cubic feet; Provence-Doxford oil engine, 60.SBD.3., 3000 h.p.—Trial, September.

ARNET ROBINSON, pilot vessel; built by Philip and Son, Ltd., for the Mersey Docks and Harbour Board; length between perpendiculars 165ft, breadth 31ft 6in, depth moulded 14ft 6in; service speed 12½ knots; two 640 b.h.p. National diesel engines, each driving 375kW and 80kW generators in tandem, one General Electric single armature propulsion motor, 920 s.h.p. at 300 r.p.m.—Launch, October 8.

ALARIC, cargo ship; built at Govan by Harland and Wolff, Ltd., for the Shaw Savill and Albion Company, Ltd.; length between perpendiculars 440ft, breadth moulded 64ft, depth moulded to shelter deck 39ft, deadweight 9000 tons, service speed 17 knots; three continuous decks, five cargo holds, bale capacity 540,000 cubic feet, one 70-ton, one 25-ton, four 10-ton, six 5-ton and six 3-ton derricks, electric winches; four 175kW diesel-driven generators, one 40kW diesel-driven auxiliary generator; one single-acting, two stroke, opposed piston, Harland and Wolff oil engine, six cylinders, 750mm diameter by 2000mm combined stroke, 10,000 b.h.p., 120 r.p.m.—Launch, October 8.

WEYBRIDGE, cargo liner; built by Barclay Curle and Co., Ltd., for the Britain Steamship Company, Ltd.; length overall 487ft, breadth 63ft, depth to bridge deck 47ft, gross tonnage 9300; six holds, two 20-ton derricks, and one to lift 10 tons; electric deck machinery; two 290kW diesel-driven generators, one 300kW gas turbine-driven generator, one 82kW diesel-driven stand-by generator; Barclay Curle-Doxford diaphragm opposed piston oil engine, six cylinders, 670mm diameter by 2320mm combined stroke, Bibby detuner flywheel.—Launch, October 8.

DULWICH, raised quarter deck collier; built by Hall Russell and Co., Ltd., for the South Eastern Gas Board; length between perpendiculars 261ft 6in, breadth moulded 39ft 4in, depth moulded 18ft 6in, deadweight 2835 tons; three holds, electric deck machinery; eight-cylinder British Polar diesel engine, 1150 b.h.p., 225 r.p.m.—Trial, October 10.

KORAKI, cargo ship; built by Alexander Stephen and Sons, Ltd., for the Union Steam Ship Company of New Zealand, Ltd.; length 325ft, breadth 51ft, depth 26ft, deadweight 5300 tons; three holds, twelve derricks, MacGregor single-pull steel hatch covers, electric winches; Stephen-Sulzer single-acting diesel engine, six cylinders, 600mm diameter by 1040mm stroke, 2410 b.h.p. at 128 r.p.m., 3000 overload brake horsepower at 150 r.p.m.—Trial, October 15.

STAR OF LATHALLAN, trawler; built by John Lewis and Sons, Ltd., for the Walker Steam Trawl Fishing Company, Ltd.; length between perpendiculars 115ft, breadth 25ft, depth 12ft, fish room capacity 6000 cubic feet, electric trawl winch to take 1000 fathoms of 2¾in warp; Mirrlees K.S.6. diesel engine, 690 b.h.p. at 250 r.p.m.—Trial, October 15.

SPINANGER, oil tanker; built by Joseph L. Thompson and Sons, Ltd., for Westfal-Larsen and Co. A/S., Norway; length between perpendiculars 530ft 2½in, breadth moulded 71ft 10½in, depth moulded 40ft, deadweight 19,000 tons on 30ft 3in summer draught; service speed 14½ knots; eight centre and eighteen wing cargo oil tanks; Doxford, turbo-charged, diaphragm opposed piston oil engine, six cylinders, 650mm diameter by 2320mm combined stroke, 8000 b.h.p. at 115 r.p.m.—Launch, October 22.

PACIFIC ENVOY, cargo and passenger liner; built at the Walker Naval Yard by Vickers-Armstrongs, Ltd., for Furness, Withy and Co., Ltd.; length 501ft, breadth 63ft 2in, depth 41ft, deadweight 10,700 tons, draught loaded 28ft 6in, refrigerated capacity 140,000 cubic feet; twelve passengers; two complete decks; service speed 15½ knots; Parsons geared turbine machinery.—Launch, October 23.

THACKERAY, cargo ship; built by Henry Robb, Ltd., for the Chine Shipping Company, Ltd.; length between perpendiculars 345ft, breadth moulded 54ft, depth moulded to upper deck 29ft, deadweight 6600 tons on 23ft 6in mean draught, service speed 12·5 knots; four holds, capacity 290,000 cubic feet, eight 5-ton derricks, electric hydraulic winches; three 106kW diesel-driven generators; Sulzer diesel engine, six cylinders, 3000 b.h.p. at 150 r.p.m.—Launch, October 24.

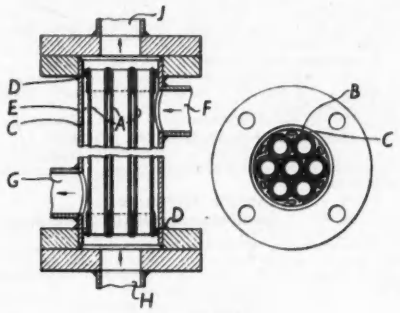
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

HEAT EXCHANGERS

786,074. December 29, 1954.—HEAT EXCHANGERS OF THE TUBULAR TYPE, Aktiebolaget Rosenblads Patenter, Kommendörsgatan, 16, Stockholm, Sweden. (*Inventors: Gustav Conrad Egenwall* and *Oscar Persson.*)

The invention relates to indirect heat exchangers, and it has for its object to provide a construction which enables thin-walled tubes to be welded together in closely spaced relation to each other while satisfying high demands in respect of non-defective welding as well as mechanical strength of the resulting joints.



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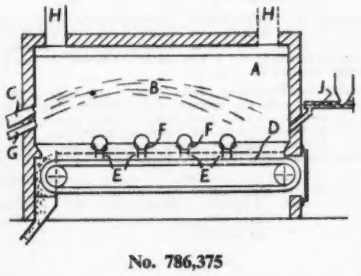
The heat exchanger illustrated in the drawing comprises a bundle of tubes *A* interconnected in accordance with the invention at both ends. In this case, the perforate plate constituted by the tube sleeves *B* is formed into a tube end plate by being provided about its periphery with material forming a casing *C*, which surrounds the bundle of tubes, the bridging material in this case consisting of a flange *D*, together with welding. Thus, around the bundle of tubes, there is formed in conventional manner a chamber *E* through which one of the heat exchanging fluids can be caused to pass through the interspaces from an inlet *F* to an outlet *G*, the other fluid being conducted in counterflow relative from an inlet *H* through the tubes to an outlet *J*. It will be readily seen that the arrangement provides for a compact construction of the heat exchanger, and that the cross-sectional area externally of the tubes can be devised to be unusually small, enabling a high rate of flow to give a good heat transfer. Several designs are shown in the specification.—*November* 13, 1957.

METALLURGY

786,375. October 5, 1954.—THE ROASTING OF SULPHIDE ORES, Krebs and Cie, 38, rue Parmentier, Neuilly-sur-Seine, Seine, France.

In accordance with the invention, it has been found that it is possible to reduce considerably the required conditions in respect of the fineness of grinding by employing a mixed process which comprises injecting a suspension of the ore into a non-externally heated chamber. The ore after injection falls down in a trajectory depending on the size of the particles of the ore and collects as a layer in the lower portion of



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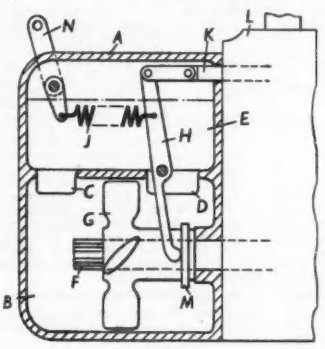
the chamber, introducing a free oxygen containing gas into the lower portion of the chamber, so that the ore particles are not only roasted while in suspension by ascending oxygen-containing gas, but are also roasted by contact with oxygen-containing gas while in layer, and withdrawing the spent oxygen-containing gas from the upper part of the chamber. In the furnace shown in the drawing, the ore is introduced at one end *A* in the form of a "sheet" *B* by means of one or a number of nozzles *C*. The combustion of the finest particles takes place immediately, and that of the larger grains more slowly. As will be appreciated from the drawing, it is the larger grains which have the longest trajectory and are therefore exposed for the longest time to the atmosphere of the furnace and on the sole plate *D*. The sole plate is in the form of a travelling band as shown. Raking devices *E* are fixed to conduits through which air is introduced above the level of ore by means of openings *F*. This air serves also to cool the raking devices. In order to limit the temperature inside the furnace, an inert gas is injected through one or more nozzles *G* adjacent to the point of injection of the ore and preferably beneath it. A gas outlet *H* is arranged at one of the extremities of the furnace, preferably close to the point of entry of the ore, as shown in full lines, although it could also be positioned as shown in dotted lines. Any sulphated or incompletely roasted dust entrained in the gas stream may be separated therefrom after it leaves the furnace and reintroduced on to the sole plate by means of a screw *J*, so that the last traces of sulphur may be removed from it. Alternative forms of the invention are also shown in the specification.—*November* 20, 1957.

INTERNAL COMBUSTION ENGINES

786,442. April 28, 1955.—SPEED GOVERNORS, C.A.V., Ltd., Warple Way, Acton, London, W.3. (*Inventor: Marek Jakubowski.*)

The invention has for its object to provide in a simple form a speed governor for a prime mover. The drawing illustrates a typical embodiment of the invention as applied to a liquid fuel pump for an internal combustion engine. There is provided in a housing *A* a cylindrical chamber *B*, having at its opposite ends ports or passages *C* and *D* communicating with an upper chamber *E*. Into the cylindrical chamber extends the pump driving shaft *F*, which is driven by the engine, and on this shaft is slidably mounted an axial-flow impeller *G* of approximately the same diameter as the chamber. Within the housing is pivoted a lever *H* loaded by a spring *J*, one end



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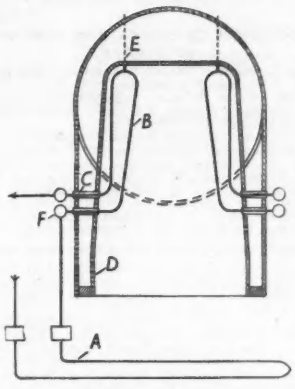
of the lever being connected to a slidable bar *K* forming part of the output control means of the pump, the housing being mounted on one end of the pump casing *L*. The other end of the lever abuts against one side of a collar *M* on the central boss of the impeller. Preferably the spring *J* acting on the lever is attached at one end to a manually operable lever *N*, whereby the force exerted by the spring on the lever *H* can be adjusted. The housing is filled with any convenient liquid, such as fuel or lubricating oil, to maintain the chamber *B* in a full condition. When the impeller is rotating, it causes an axial flow of the liquid to occur through it, the liquid displaced from one side of the impeller being discharged to the other chamber and thence returned to the other side of the impeller. The axial reaction of the liquid on the impeller is a function of the speed, and the impeller will move axially on the shaft in opposition to the spring to an extent dependent on the speed, this movement being utilised to operate the lever and thereby reduce the rate of supply of fuel to the engine with increasing speed. The invention is applicable in essentially the same manner to other prime movers. —*November* 20, 1957.

RAILWAY ENGINEERING

786,307. August 8, 1955.—SUPERHEATING ARRANGEMENT FOR STEAM-DRIVEN VEHICLES, ESPECIALLY LOCOMOTIVES, Helmut Robert Friedrich Kaulla, Ph.D., 53, Bougainville Street, Forrest, Canberra, Australia.

A manner of carrying out the invention is shown in the drawing. It shows diagrammatically the radiation component of a superheater with the convection component *A* being arranged in series and separated from the superheater. The ends of the superheater elements *B* extend through hollow staybolts *C*, which connect the inner with the outer firebox. Inside the firebox *D* the superheater elements *B* are extended upwards; in the vicinity of the crownsheet they are formed into single or double or multiple loops. The elements, in addition, are held by a support attached to a roof stay *E* or otherwise. Instead, with a loop or loops, the elements may be fitted with return bends



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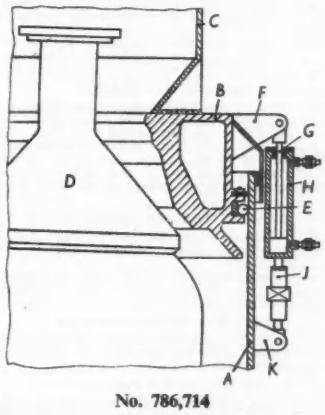
and in such case may be extended below the crownsheet. The hollow staybolts *C* may be positioned above the brick arch; the elements will then not be subject to radiation from the grate. Each superheater element is introduced separately into the firebox through the grate opening after removal of some of the fire-bars, the ends led through the hollow stays *C* and connected to the headers *F*; these are protected against heat losses by a casing, not shown, that may also enclose the part of the elements between the header and the outer firebox. In a modification of the form shown, should the firebox be fitted with a combustion chamber, the headers are arranged near the boiler barrel, parallel to its axis, e.g. below the boiler and the superheater elements located in the combustion chamber.—*November* 13, 1957.

STONE CRUSHERS

786,714. May 7, 1956.—GYRATORY CONE CRUSHERS, Westfalia Dinnendahl Gröppel, Aktiengesellschaft, Bochum, Germany.

The invention relates to a gyratory cone crusher, in which the outer crushing member is supported hydraulically. This hydraulic mode of support has the object of enabling the outer crushing member to yield, on the occurrence of an unbreakable piece in the crusher gap, so as to prevent damage to the machine. In the drawing it will be seen that into the crusher casing *A* is inserted the outer crushing member *B*, which, at its upper end, supports the charging hopper *C*. The crusher cone is shown at *D*. The outer crushing member *B* is guided on the inside of the crusher casing by any suitable means—for instance,



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by a ball ring *E*—so as to be axially displaceable. In addition, the outer crushing member *B* is provided at its periphery with brackets *F* to the outer ends of which are pivotally attached the pistons *G* of hydraulic supporting means. The pistons are guided in pressure cylinders *H* against the bottoms of which they abut, when the crusher is in the operative position, and are held by the pressure of the oil. The cylinders *H* have at their lower ends holding devices *J* which are adjustable and which are pivotally attached to brackets *K* fixed to the outside of the casing. By turning the holding devices *J* the cylinders *H* can be raised or lowered, and by this means the outer crushing member *B* be adjusted axially with respect to the crusher cone. —*November* 20, 1957.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Wed., Jan. 1.—PRESTON BRANCH : R.A.F.A. Club, East View, Preston, "Railway Electrification," K. Taylor, 7.30 p.m. ★ NORTH LONDON BRANCH : "Queen's Head," 677, Green Lanes, Harringay, London, N.4, Film, "Electrical Engineers' (ASEE) Exhibition, 1957," 7.45 p.m.

Thurs., Jan. 2.—SOUTHAMPTON BRANCH : Pilgrim Room, Polygon Hotel, Southampton, "Traffic Control," E. Bailey, 8 p.m.

Fri., Jan. 3.—LIVERPOOL BRANCH : Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, 2, "General Factory Requirements for Electrical Installations," D. A. Picken, 7.30 p.m. ★ BRISTOL AND WEST OF ENGLAND BRANCH: Grand Hotel, Broad Street, Bristol, "Reinforced Concrete Construction," J. Barrett, Film, "Prestressed Concrete," 8 p.m

BRITISH INSTITUTION OF RADIO ENGINEERS

Tues., Jan. 7.—LONDON SECTION : London School of Hygiene and Tropical Medicine, Keppell Street, Gower Street, London, W.C.1, Discussion on "Mass Production of Television Tuners," opened by P. C. Ganderton, 6.30 p.m.

Wed., Jan. 8.—WEST MIDLANDS SECTION : Wolverhampton and Staffordshire Technical College, Wulfruna Street, Wolverhampton, "Instrumentation of Space Vehicles," N. R. Nicoll, 7.15 p.m. ★ NORTH EASTERN SECTION : Institution of Mining and Mechanical Engineers, Neville Hall, Westgate Road, Newcastle upon Tyne, "The Earth Satellite Project," P. H. Tanner, 6 p.m.

Thurs., Jan. 9.—SCOTTISH SECTION : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Electronic Calculator Circuitry," F. Baillie, 7 p.m.

BRITISH INTERPLANETARY SOCIETY

Sat., Jan. 4.—Tudor Room, Caxton Hall, London, S.W.1, "High Altitude Research during the International Geophysical Year," R. F. L. Boyd, 6 p.m.

ILLUMINATING ENGINEERING SOCIETY

Thurs., Jan. 2.—NOTTINGHAM CENTRE : Demonstration Theatre, East Midlands Electricity Board, Smithy Row, Nottingham, "Lighting from the Contractor's Point of View," N. C. Slater, 6 p.m.

Wed., Jan. 8.—EDINBURGH CENTRE : Y.M.C.A., Social Room, 14, South St. Andrew Street, Edinburgh, "The Sales Engineer's Approach to Lighting," W. J. Burland, 6.15 p.m. ★ SWANSEA GROUP : Demonstration Theatre, South Wales Electricity Board, The Kingsway, Swansea, "Lighting for Photography," R. W. Unwin, 6.30 p.m.

Thurs., Jan. 9.—CARDIFF CENTRE : Demonstration Theatre, South Wales Electricity Board, The Hayes, Cardiff, "Lighting for Photography," R. W. Unwin. 7.30 p.m.

INCORPORATED PLANT ENGINEERS

Wed., Jan. 1.—LEICESTER BRANCH: Bell Hotel, Leicester, "Smoke Abatement," S. N. Duguid, 7 p.m.

Tues., Jan. 7.—EDINBURGH BRANCH : 25, Charlotte Square, Edinburgh, "Construction of a Welded Pipe Line," R. Downie, 7 p.m. ★ LONDON BRANCH : Royal Society of Arts, John Adam Street, Adelphi, Strand, London, W.C.2, "A Practical Survey of Automatic Combustion Regulation on Industrial Boilers," W. R. L. Kent, 7 p.m. ★ PETERBOROUGH BRANCH : White Lion Hotel, Church Street, Peterborough, "Production and Maintenance in an Automobile Factory," K. B. O'Kell, 7.30 p.m.

Wed., Jan. 8.—EAST MIDLANDS BRANCH : Sherwood Room, County Hotel, Theatre Square, Nottingham, "The Petroleum Industry," J. Collins, 7 p.m. ★ WESTERN BRANCH : Grand Hotel, Bristol, "Education in Industry," E. G. Sterland, 7.15 p.m.

Thurs., Jan. 9.—GLASGOW BRANCH : Scottish Building Centre, 425/427, Sauchiehall Street, Glasgow, Open Discussion, 7.15 p.m. ★ NORTH EAST BRANCH : Roadway House, Oxford Street, Newcastle upon Tyne, "The Road to the Future," B. Rogers, 7 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Tues., Jan. 7.—SLOUGH SECTION : Lecture Theatre, High Duty Alloys, Ltd., Slough, "Pressure-die-casting," H. J. Sharp, 7.30 p.m.

Thurs., Jan. 9.—BEDS AND HERTS SECTION : K. and L. Steelfounders and Engineers, Ltd., Letchworth, "Aids to Automation," J. A. Hufton, 7.30 p.m.

INSTITUTE OF FUEL

Wed., Jan. 8.—Institution of Civil Engineers, Great George Street, London, S.W.1, "The Influence of the Adsorption of Frothing Agent on the Percentage Recovery of Coal from Flotation Pulps," A. Jowett, 5.30 p.m. ★ SOUTH WALES SECTION : Steel Company of Wales, Canteen Hall, Abbey Works, Port Talbot, "Planning Construction and Problems Associated with Berkeley and Dounreay Power Stations," P. K. Richards, 6 p.m.

INSTITUTE OF METALS

Tues., Jan. 7.—OXFORD LOCAL SECTION : Cadena Café, Cornmarket Street, Oxford, Junior Members' Meeting, "Seeing Dislocations," 7 p.m.

Thurs., Jan. 9.—BIRMINGHAM LOCAL SECTION : College of Technology, Gosta Green, Birmingham, "The Production of Rod and Shapes in Copper and its Alloys," N. Swindells, 6.30 p.m.

INSTITUTE OF PETROLEUM

Wed., Jan. 1.—26, Portland Place, London, W.1, "Lubrication Problems Arising from Railway Traction Modernisation," W. B. Broadbent and G. A. Dickins, 5.30 p.m.

INSTITUTE OF PHYSICS

Fri., Jan. 3.—LIVERPOOL AND NORTH WALES BRANCH : Department of Electrical Engineering, The University, Liverpool. "Radio Astronomy," H. P. Palmer, 7 p.m.

INSTITUTE OF REFRIGERATION

Thurs., Jan. 2.—Junior Institution of Engineers, Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Properties, Handling and Storage of Modern Refrigerants," W. F. Bews, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Thurs., Jan. 2.—WEST REGIONAL CENTRE : Liverpool Architectural Society's Rooms, Bluecoat Chambers, School Lane, Liverpool, 1, "Management and Personnel Control," 7.30 p.m.

Mon., Jan. 6.—SCOTTISH CENTRE : Institution of Engineers and Shipbuilders, Elmbank Crescent, Glasgow, "Air Brakes and Auxiliaries for Commercial Vehicles," W. A. Kirk, 7.30 p.m.

Wed., Jan. 8.—SOUTHERN CENTRE : Technical Institute, Brighton, "Gas Turbines and their Application to Road Transport," A. Enticknap, 7.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Jan. 7.—Great George Street, London, S.W.1, "No. 1 Berth, Tilbury Dock, Port of London Authority," C. Peel, A. J. Carmichael and R. F. J. Smeardon, 5.30 p.m.

Wed., Jan. 8.—Great George Street, London, S.W.1, Dugald Clerk Lecture, "Lifting Equipment," W. R. Hockaday, 6.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Wed., Jan. 1.—SOUTHERN CENTRE : Central Electricity Authority, Portsmouth, Joint Meeting with Southern Association of Institution of Civil Engineers, "Cathodic Protection," L. B. Hobgen, K. A. Spencer and P. W. Heselgrave, 6.30 p.m.

Fri., Jan. 3.—SOUTH WESTERN SUB-CENTRE : Central Hall, Plymouth, "Lighting," H. Cotton, 3 p.m.

Mon., Jan. 6.—NORTH LANCASHIRE SUB-CENTRE : North Western Electricity Board Demonstration Theatre, 19, Friargate, Preston, "The B.B.C. Sound Broadcasting Service on Very High Frequencies," E. W. Hayes and H. Page, 7.15 p.m. ★ SOUTH MIDLAND CENTRE : James Watt Memorial Institute, Great Charles Street, Birmingham, "Electrical Equipment for Rectifier Locomotives," H. B. Calverley, E. A. K. Jarvis and E. Williams, 6 p.m.

Tues., Jan. 7.—LONDON GRADUATE AND STUDENT SECTION : Savoy Place, London, W.C.2, Address by the President, T. E. Goldup, 6.30 p.m. ★ MEASUREMENT AND SUPPLY SECTIONS : Savoy Place, London, W.C.2, "The Breakdown of Transformer Oil under Impulse Voltages," R. Hancox and H. Tropper, 5.30 p.m. ★ EAST MIDLAND CENTRE : College of Arts and Crafts, Waverley Street, Nottingham, "Earth Electrode Systems for Large Electric Stations," J. H. Humphries, 6.30 p.m. ★ NORTH MIDLAND CENTRE : Central Electricity Authority, Yorkshire Division, 1, Whitehall Road, Leeds, "Power System Protection, with Particular Reference to the Application of Junction Transistors to Distance Relays," and "A Dual-Comparator Mho-Type Distance Relay Utilising Transistor," C. Adamson and L. M. Wedephol, 6.30 p.m. ★ NORTH-WESTERN CENTRE : Engineers' Club, 17, Albert Square, Manchester, "The Development of Variable-Speed High Power Drives for Large Wind Tunnels," and "A Variable-Frequency Power Installation for Large Wind-Tunnel Drives," P. McKearney, L. S. Drake and E. G. Mallalieu, 6.15 p.m. ★ SOUTH WEST SCOTLAND SUB-CENTRE : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "Brushless Variable-Speed Induction Motors," F. C. Williams, E. R. Laithwaite and L. S. Piggott, 7 p.m.

Wed., Jan. 8.—OXFORD BRANCH : Southern Electricity Board, 37, George Street, Oxford, "The Ground and Air Control of International Civil Airlines," A. E. Jaquemet and B. B. Clemon, 7 p.m. ★ SOUTH EAST SCOTLAND SUB-CENTRE : Carlton Hotel, North Bridge, Edinburgh, Supply Section Chairman's Address, "Too Much and Too Little," M. G. Say, 7 p.m. ★ SOUTHERN CENTRE: R.A.E. Technical College, Farnborough, "Colour Television," C. J. Stubbington, 6.30 p.m.

Thurs., Jan. 9.—Savoy Place, London, W.C.2, "The Development of Variable-Speed High-Power Drives for Large Wind Tunnels," and "A Variable-Frequency Power Installation for Large Wind-Tunnel Drives," P. McKearney, L. S. Drake and E. G. Mallalieu; "Speed Control of Large Wind Tunnels, with Particular Reference to the R.A.E. 8ft by 8ft High Speed Wind Tunnel," L. S. Drake, J. H. Fox and G. H. A. Gunnell; "Data-Setting and Electrical Control Gear for the Flexible Nozzle and Diffuser of a High Speed Wind Tunnel," C. R. Dunham, 5.30 p.m. ★ NORTH SCOTLAND SUB-CENTRE : Electrical Engineering Queen's College, Dundee, "The Remote and Automatic Control of Semi-Attended Broadcasting Transmitters," R. T. B. Wynn and F. A. Peachey, 7 p.m. ★ WEST WALES (SWANSEA) SUB-CENTRE : Conference Rooms, South Wales Electricity Board Showrooms, The Kingsway, Swansea, "Electrical Floor Warming," J. W. Moule and W. M. Stevenson, "Development of Transportable Thermal-Storage Space Heaters," E. Bates, 6 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

Tues., Jan. 7.—EAST ANGLIA BRANCH : Assembly House, Norwich, "Steel—Modern Applications of Rolled Sections," F. G. Ward, 6.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Thurs., Jan. 2.—WESTERN A.D. CENTRE : Royal Hotel, Bristol, Informal Meeting, 6.45 p.m. ★ YORKSHIRE GRADUATES' SECTION : Grand Hotel, Sheffield, "Liaison Between Design and Production," W. Edwards, 6.30 p.m.

Mon., Jan. 6.—LIVERPOOL PANEL : Royal Institution, Colquitt Street, Liverpool, "British Columbia - Vancouver Island 138kV Submarine Power Cable," Messrs. Ingledow, Fairfield Davey, Brazier and Gibson, 6.30 p.m.

Wed., Jan. 8.—EAST MIDLANDS BRANCH : Lecture Theatre, Loughborough College of Technology, Greenclose Lane, Loughborough, Annual Meeting; "Numbers, Statistics and Computers in the Engineering Industry," H. McGregor Ross, 7 p.m. ★ LUTON A.D. CENTRE : Assembly Room, Town Hall, Luton, "Pneumatic Suspensions for Motor Vehicles," J. Sainsbury, 7.30 p.m.

INSTITUTION OF NAVAL ARCHITECTS

Thurs., Jan. 9.—Weir Lecture Hall, 10, Upper Belgrave Street, London, S.W.1, Amos Ayre Lecture, "The Evolution of the Cargo Ship During the Last 35 Years, and Some Thoughts on the Years to Come," J. Ramsay Gebbie, 4.45 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Mon., Jan. 6.—Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2, "The Introduction of Subscriber Trunk Dialling," A. J. Thompson and N. Walker, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Thurs. and Fri., Jan. 2 *and* 3.—The University, Southampton, Sixth Conference on "Problems of Aircraft Production," Theme, "U.S.-U.K. Practice."

Fri., Jan. 3.—LIVERPOOL GRADUATE SECTION : Stork Hotel, Queen's Square, Liverpool, "Aircraft Design," F. F. Heaton, 7.30 p.m.

Wed., Jan. 8.—WOLVERHAMPTON SECTION : Technical College, Dudley, "The Russian Machine Tool Industry," N. Stubbs and P. Trippe, 7.15 p.m. ★ NOTTINGHAM SECTION : Victoria Station Hotel, Nottingham, Graduate Meeting, 7 p.m. ★ LIVERPOOL SECTION : Exchange Hotel, Tithebarn Street, Liverpool, 2, "Inspection as an Aid to Production," W. Maiden, 7.30 p.m.

Thurs., Jan. 9.—LEICESTER SECTION : Cromwell Room, Grand Hotel, Leicester, "Use of Plastics in Industry," B. E. Terry, 7 p.m. ★ READING SECTION : Social Club, Petters, Ltd. Staines, "Practical Approach to Engineering Fine Surfaces," D. B. Ebsworth, 7.30 p.m. ★ LUTON SECTION : Staff Canteen, S.K.F., Ltd., Luton, "Recent Production Engineering Research," J. Cherry, 7.30 p.m. ★ ROCHESTER SECTION : Assembly Room, Sun Hotel, Chatham, "Pneumatic Circuiting," H. C. Orchard, 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Fri., Jan. 3.—WESTERN COUNTIES' BRANCH : Small Lecture Theatre, University Engineering Laboratories, The University, Bristol, "Construction of a Prestressed Concrete Circular Tank," G. B. Smedley, 6 p.m.

Tues., Jan. 7.—LANCASHIRE AND CHESHIRE BRANCH : College of Science and Technology, Manchester, "Shrinkage in Soils," E. Ll. Morgan, 6.30 p.m.

Thurs., Jan. 9.—11, Upper Belgrave Street, London, S.W.1, "The Calculation of Bending and Torsional Effects in Girders," J. S. Terrington, 5.55 p.m.

INSTITUTION OF WORKS MANAGERS

Mon. and Tues., Dec. 30 *and* 31.—MANCHESTER BRANCH : The University, Manchester, Christmas Lecture for Children, "Flight" P. Sutcliffe, 6.45 p.m.

Mon., Jan. 6.—TYNE-WEAR BRANCH : Conference Room, Ministry of Labour and National Service, 93a, Grey Street, Newcastle upon Tyne, "Some Aspects of Fuel Economy for the Works Managers," 6.30 p.m.

Tues., Jan. 7.—LEICESTER BRANCH : Grand Hotel, Leicester, "Safety in Industry," W. T. Hewins, 7.30 p.m.

Thurs., Jan. 9.—PRESTON BRANCH : Golden Lion Hotel, Blackburn, "Managing the Scientist," E. J. Wilkins, 7.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

Fri., Jan. 3.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Films on "X-Ray Crystallography," "Cables Round the World," "Diamond Dies for Wire Drawing," Introduced by H. P. Rooksby and E. G. Steward, 7 p.m.

LIVERPOOL METALLURGICAL SOCIETY

Thurs., Jan. 9.—The University, Liverpool, Joint Meeting with University of Liverpool Metallurgical Society, "Student Prize Competition," 7 p.m.

PLASTICS INSTITUTE

Thurs., Jan. 2.—William Beveridge Memorial Hall, Senate House, London University, W.C.1, Lecture for Young People, "The Progress of Plastics," C. E. H. Bawn, 2.30 p.m.

Wed., Jan. 8.—SOUTH WALES AND MONMOUTHSHIRE SECTION : Angel Hotel, Cardiff, "New Developments in Unsaturated Polyester Resins," H. Williams, 7 p.m.

ROYAL AERONAUTICAL SOCIETY

Thurs., Jan. 2.—Royal Society of Arts, 6, John Adam Street, London, W.C.2, Young People's Lecture, A. W. Bedford, 3 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., Jan. 6.—12, Great George Street, Westminster, London, S.W.1, "Aerial Survey of Graham Land in British Antarctica," P. G. Mott and J. H. Saffery, 5.45 p.m.

ROYAL SOCIETY OF ARTS

Wed., Jan. 1.—John Adam Street, Adelphi, London, W.C.2 Juvenile Lecture, "Into Space," P. Moore, 2.30 p.m.

Mon., Jan. 6.—John Adam Street, Adelphi, London, W.C.2, Juvenile Lecture, "Cloth from the Chemist," J. R. Whinfield, 2.30 p.m.

SHEFFIELD METALLURGICAL ASSOCIATION

Tues., Jan. 7.—B.I.S.R.A., Hoyle Street, Sheffield, Annual General Meeting of Methods of Analysis Group : Address by the Chairman, 7 p.m.

SOUTH WALES INSTITUTE OF ENGINEERS

Thurs., Jan. 9.—Institute Buildings, Park Place, Cardiff, "Some Aspects of the Design and Erection of Skyscraper Buildings," L. G. Johnson, 6 p.m.

Advanced Engineering Courses

Engineering and Metallurgical Aspects of Fatigue. BATTERSEA COLLEGE OF TECHNOLOGY, METALLURGY DEPARTMENT, Battersea Park Road, London, S.W.11. Course of ten lectures, Tuesdays, 7 to 9 p.m., commencing January 14, 1958. The course is designed to cover both modern industrial practice and recent theoretical developments. Fee £1.

Modern Electric Network Theory and Design. SOUTH EAST LONDON TECHNICAL COLLEGE, DEPARTMENT OF ELECTRICAL ENGINEERING AND APPLIED PHYSICS, Lewisham Way, London, S.E.4. Course of six lectures, Wednesdays, 7 to 9 p.m., commencing January 22. Fee 10s.

Dynamical Similarity and Dimensional Analysis. DEPARTMENT OF MECHANICAL ENGINEERING, Brownlow Hill, The University, Liverpool. A University extension course of ten lectures, Tuesdays, 5.30 to 7 p.m., commencing January 7. Fee £2 12s. 6d.

Introduction to Electronics. DEPARTMENT OF ELECTRICAL ENGINEERING, Brownlow Hill, The University, Liverpool. A University extension course of ten lectures, Fridays, 5.30 to 7 p.m., commencing January 10. Fee £2 12s. 6d.

Application of Work Study. UNIVERSITY OF BIRMINGHAM, INSTITUTE FOR ENGINEERING PRODUCTION, "Southfield," 16, Norfolk Road, Edgbaston, Birmingham, 15. Residential executive course from 9.30 a.m., Monday, January 13, to 4 p.m., Friday, January 24. Fee £50.

Automatic Data Processing. JOHN DIEBOLD AND ASSOCIATES INC., New York, with the support of the BRITISH INSTITUTE OF MANAGEMENT. Washington Hotel, Curzon Street, London, W.1. A five-day course for management, January 20 to 24. Fee 85 guineas. Inquiries to the British Institute of Management, Management House, 80, Fetter Lane, London, E.C.4.

Queueing : Theory and Practice. UNIVERSITY OF BIRMINGHAM, INSTITUTE FOR ENGINEERING PRODUCTION, "Southfield," 16, Norfolk Road, Edgbaston, Birmingham, 15. Residential executive course, 9.15 a.m., Monday, January 6, to 3.45 p.m., Friday, January 10. Fee £30.

END OF VOLUME 204

PUBLIC APPOINTMENTS

ROYAL AIRCRAFT ESTABLISHMENT TECHNICAL COLLEGE, FARNBOROUGH, HANTS

LECTURERS

Applications are invited for the following vacancies n the above selective College :

Post 1 : LECTURER IN AIRCRAFT STRUCTURES.

Post 2 : LECTURER IN ENGINEERING DESIGN.

Candidates should hold University Degrees or equivalent, and preferably have some industrial and/or teaching experience. Candidates for Post 1 should be capable of accepting the responsibility for the teaching of the subject for the final B.Sc. (Eng.) London University, Higher National Certificate, A.F.R.Ae.S., and possibly Diploma in Technology. Candidates for Post 2 should be capable of developing, organising and teaching the subject throughout the College. A new Higher National Certificate scheme is being devised to train design engineers. A suitable successful candidate for either of the above posts may be invited to accept the additional duties of O.C. College Experimental Flight Testing Training, for which a special additional allowance may be paid. Successful candidates will be invited to commence duties as soon as possible.

The salaries payable are in accordance with the Burnham Scale for Teachers in Technical Colleges and are subject to the Teachers' Superannuation Acts. Commencing salary in accordance with experience, on scale £1200 by £30 to £1350.

Details and application forms from the Principal of College, to whom completed forms should be returned. E9616

STAFFORDSHIRE POTTERIES WATER BOARD

APPOINTMENT OF CIVIL ENGINEERING ASSISTANTS AND DRAUGHTSMEN

Applications are invited for the following appointments :—

(1) CIVIL ENGINEERING ASSISTANTS, Grade A.P.T.III (£845 to £1025 p.a.).

Applicants should be Corporate Members of the Institution of Civil Engineers, and preferably had experience in the design and construction of waterworks.

(2) DRAUGHTSMAN, CIVIL ENGINEERING, Grade A.P.T. I (£575 to £725 p.a.).

Applicants should be neat and expeditious draughtsmen and should have knowledge of civil engineering and surveying.

(3) DRAUGHTSMAN, ARCHITECTURAL, Grade A.P.T. I (£575 to £725 p.a.).

Applicants should be neat and expeditious draughtsmen and had experience in architectural work.

(4) DRAUGHTSMAN, DISTRIBUTION DEPARTMENT, Grade A.P.T. I (£575 to £725 p.a.).

Applicants should be neat and expeditious draughtsmen and previous experience with a waterworks undertaking is desirable, but not essential.

For appointment (1) the Board will provide housing accommodation to the successful candidate if required. Reasonable removal expenses will be allowed by the Board.

The appointments are subject to the provisions of the National Scheme of Conditions of Service ; to the provisions of the Local Government Superannuation Act, 1937 ; to termination by one month's notice on either side, and to the successful candidates passing a medical examination.

The Board have considerable major works in hand, giving opportunities of preparing designs, specifications, and supervising contracts for varied types of work.

Applications, stating age, full details of training, qualifications, present and previous appointments, details of experience, together with copies of two recent testimonials, or the names of two persons to whom reference can be made, and clearly stating for which post they are applying, should be forwarded to the undersigned not later than the 12th January, 1958.

C. V. BROWN,
M.I.C.E., M.I.Mech.E., M.I.W.E.,
Engineer and Manager and Clerk.
Staffordshire Potteries Water Board,
Albion Street,
Hanley,
Stoke-on-Trent. E9642

MINISTER OF INTERIOR OF IRAQ, BAGHDAD

CHIEF ENGINEER

The Minister of Interior of Iraq, Baghdad, invites applications from qualified Municipal or Civil Engineers for the posts of CHIEF ENGINEER in the Municipalities of Mosul and Basrah. Applicants should hold a University Degree in Engineering and be conversant with road construction, building, drainage and sewerage and town planning. Practical experience in a Municipal Service will be an advantage.

The appointment will be on contract for a period of two years and will be renewable after satisfactory service. Salary will be in the scale of £175 to £250 per month, dependent on qualification, age and practical experience.

Conditions of service are laid down in a contract form, giving also information about the journey of appointee and his family from country of residence to Iraq, leave, provident fund, &c., which will be sent to interested candidates on request, by the Iraqi Royal Embassy or Legation concerned.

Applicants should state their age, qualification and Degree(s), practical experience and salary requested, and submit their applications to the Minister within a period of 6 weeks after the publication of this announcement. E9609

MUNICIPAL BOARD OF MOMBASA

APPOINTMENT OF MUNICIPAL ENGINEER

Applications are invited for the above appointment from persons with considerable local government engineering experience, aged 45 years or under, who are Associate Members of the Institution of Civil Engineers, or Associate Members of the Institution of Municipal and County Engineers or equivalent. Associate Membership of the Institution of Water Engineers and Associate Membership of the Town Planning Institute will be an added advantage

Salary scale : £2250 by £75 to £2850 per annum

Housing provided at a rental of 10 per cent of salary.

Superannuation scheme, requiring contribution of 9 per cent of salary with a pension constant of 1/50th for each completed year of contributory service. Retiring age 55 years.

Three-year tour of service, after which six months' leave on full salary may be granted with passages to United Kingdom up to a maximum of three adult passages in accordance with Board's Regulations. Three periods of local leave of 21 days' duration may be granted during tour of service.

Passages on appointment are provided by Board in accordance with the regulations and half salary is paid during voyage.

Board provide medical attention for their staff in accordance with regulations.

Full particulars of rates of income tax, cost of living and other matters relating to Kenya may be obtained from the East African Commissioner at Grand Buildings, Trafalgar Square London, W.C.1.

Applications, in writing, stating date and place of birth, details of qualifications and experience, the date the applicant could assume duty, copies of three recent testimonials and a recent photograph should be addressed by air mail to the Town Clerk, P.O. Box 440, Mombasa, Kenya, so as to arrive not later than 18th January, 1958. Canvassing will disqualify.

A. V. RATCLIFF,
Town Clerk.
Town Hall,
Mombasa,
30th November, 1957. E9574

BOROUGH OF SHREWSBURY

WATER DEPARTMENT

APPOINTMENT OF AN ASSISTANT ENGINEER

Applications are invited for the above established appointment. Salary : A.P.T. Scale, Grade II (£725–£845).

Housing accommodation will be provided if required and removal expenses paid.

The appointment is subject to the N.J.C. Conditions of Service, the Local Government Superannuation Acts, a satisfactory medical examination, and termination by one month's notice on either side.

Applications, stating age, qualifications and details of experience, together with the names of three persons to whom reference may be made, should be submitted to the Water Engineer and Manager, Water Department, Shelton, Shrewsbury, so as to be received not later than the 11th January 1958.

S. R. H. LOXTON,
Town Clerk.
Guildhall,
Shrewsbury. E9611

CITY OF CARDIFF

CORPORATION WATERWORKS

DEPUTY WATER ENGINEER AND MANAGER

Applications are invited for the position of DEPUTY WATER ENGINEER AND MANAGER in the salary scale commencing £1560 and rising by annual increments of £70 to £1770, with a car allowance on the Corporation Scale.

Candidates must be Chartered Civil Engineers and Corporate Members of one other professional Engineering Institution, and have had considerable experience in the design, construction and operation of a large water undertaking.

General conditions of appointment and forms of application may be obtained from the Water Engineer and Manager, City Hall, Cardiff, and applications, in envelopes endorsed "Deputy Water Engineer," returned to me by 8th January, 1958.

S. TAPPER-JONES,
Town Clerk.
City Hall,
Cardiff.
11th December, 1957. E9585

HORTHAM-BRENTRY HOSPITAL MANAGEMENT COMMITTEE

ASSISTANT ENGINEER

Applications invited for appointment of ASSISTANT ENGINEER at Hortham Hospital, Almondsbury, Nr. Bristol (mental deficiency : 714 beds).

Duties involve responsibility to Senior Engineer for maintenance of buildings and engineering services (including oil-fired steam boiler plant).

Applicants should have completed apprenticeship or otherwise acquired sound, practical training in mechanical engineering.

Salary : £525 by £20 (2) by £25 (2) by £30 (1) to £645 per annum. Whitley Council conditions of service. National Health Service Superannuation Scheme.

Applications, with details of age and experience, together with names of three referees, to Group Secretary by 4th January, 1958. E9615

ATOMIC ENERGY RESEARCH ESTABLISHMENT

HARWELL

INSTRUMENTATION ENGINEERS

INSTRUMENTATION ENGINEERS required at the Atomic Energy Research Establishment, Harwell, to design and commission control and instrumentation systems for research reactors and associated equipment. Applicants should be professionally qualified and have experience in industrial process control, electronics or communications circuitry.

Salary : £815–£1740, depending on age and experience.

Housing, superannuation and excellent conditions. Send postcard to Recruitment Officer (1000Y/25), A.E.R.E., Didcot, Berks, for application form and details. E9621

EDUCATIONAL

A.M.I.MECH.E., B.Sc., City and Guilds, &c. Guarantee Postal Courses for all Exams., and Technical Divisions from Elementary to Degree standard. Approximately 95 per cent. successes. 144-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E721 E

FREE ! Brochure giving details of Courses in Mechanical and Production Engineering, Draughtsmanship, &c., for the A.M.I.Mech.E., A.M.I.P.E., City and Guilds and other professional examinations. —E.M.I. Institutes, Dept. E.30 London, W.4. (Associated with H.M.V.). E972 E

TECHNICAL HOME STUDY COURSES

For A.M.I.Mech.E.,
A.M.I.Chem.E., A.M.I.M.I.,
A.F.R.Ae.S., C. & G., &c.

OVER 50 FIRST PLACES and more than 2000 Passes have been secured by T.I.G.B. Students at Professional Engineering Examinations. We have a wide range of exclusive Home Study Courses in all branches of Engineering—Mechanical, Electrical, Aeronautical, Automobile, Chemical, Gas, Radio, and Television, Draughtsmanship, &c. Textbooks, blueprints, &c., are provided and, if desired, fees may be paid by moderate instalments.—Write (stating subject of interest) for copy of 110-page Prospectus FREE and without obligation.

THE TECHNOLOGICAL INSTITUTE OF GREAT BRITAIN
(Dept. 76),
29, WRIGHT'S LANE, LONDON, W.8.
E102 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES, NOT ORIGINALS, OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED

AN EXPANDING HEAVY CHEMICAL INDUSTRY has vacancies for GRADUATE ENGINEERS (Mechanical) in one of its factories on the East Coast of England for plant maintenance and construction work. Whilst a University Degree in Mechanical Engineering is preferred, consideration will be given to outstanding applicants possessing an equivalent qualification ; age up to 40 ; salary range £1000/£1470, or higher in special cases ; annual bonus and pension schemes, also assistance for married men with house purchase and removal expenses. Applications, which will be treated in the strictest confidence.—BOX No. E935, "The Engineer." A

ASSISTANT REQUIRED to Chief Designer (Hydraulic Press Division).

Applicant must have sound engineering knowledge, preferably with hydraulic background, experience of drawing-office practice, ability to take command and must be capable of initiating and developing designs.

Contributory pension, life assurance and profit sharing bonus schemes apply. House available if required.

Write, stating age, past experience, &c., quoting S.A.D.6, to :—
The Personnel Officer,
Foster, Yates & Thom Ltd.,
Heavy Precision Engineers,
Blackburn. E9507 A

A company manufacturing Steel Racking and Shelving seeks a

COMMERCIAL MANAGER

Applicants should possess sound experience of the industry in question, should have had good all-round commercial experience at executive level and be aged 35–45. Prospects for the right man are excellent and there is a pension scheme in operation. Applicants should give full details of their qualifications and experience, their age and present salary.—BOX No. E1473, "The Engineer." A

DESIGNER for Horticultural Machinery, with experience of Lawnmowers and similar machines, required. The position will carry a good salary and participation in pension and life insurance scheme. Apply, giving full particulars of experience, salary expected.—BOX No. E9634, "The Engineer." A

Classified Advts. continued on page 4

COMPANY MEETING

HALE & HALE (TIPTON)

(Producers of Fine Blackheart Malleable Iron Castings)

EFFORTS TO COMBAT RISING COSTS

THE 21st annual general meeting of Hale and Hale (Tipton), Limited, was held on December 18th at Dudley, Mr. R. C. Leppington (Vice-Chairman and Managing Director) presiding in the unavoidable absence of the Chairman, Mr. W. Edgar Hale, M.I.Mech.E.

The following is an extract from the Chairman's circulated statement :—

The Profit and Loss Account of the Holding Company shows a Trading Profit of £82,884 as compared with £100,300 for the previous year. Taxation takes £25,162 and after various adjustments there remains a Net Profit for the year of £25,067. Your Directors propose a Final Dividend of 17½ per cent., less Tax, making 25 per cent., less Tax, for the year.

The Consolidated Trading Profit for the year amounts to £101,287, which figure compares with £118,960 for the previous year and shows a decrease of £17,673. After various adjustments there is a Profit before Taxation of £53,568 as compared with £75,113, a decrease of £21,545.

Taxation requires £29,905, and, after adjusting for excess provisions in respect of earlier years of £8256, there remains a Consolidated Net Profit of £31,919, which shows a decrease of £6156 on last year's comparable figure.

This has been a somewhat difficult year from the trading point of view, due in the early stages to the fall off in the car industry, followed by the Suez crisis, which also appreciably affected the light and heavy commercial vehicle industry, agricultural machinery makers and many other trades with which we are associated.

In conjunction with these trading setbacks we have been faced with substantial increases in raw materials, fuel and freights from the nationalised industries, together with increased wage costs.

The price margin between production cost and selling price is an ever decreasing one, as unlike the nationalised industries, we have great difficulty in recouping ; indeed, we are unable to recover the full cost of these advances from our customers.

Our programme of modernisation and improvement, however, still goes forward, as this is obviously the only way we can seriously combat rising prices and maintain our own costs at a reasonable level, also our new melting installation is now going into production, and this we hope will be the forerunner of others which will ultimately show a saving on melting costs.

The next section of our foundry mechanisation scheme should be operating within a few months which will further increase our productive potential. With a view to improving quality standards, a new finishing department has been installed and is equipped with modern power presses.

Production is now getting back to normal level and should steadily increase, provided there are no further "set-backs" waiting round the corner.

SUBSIDIARIES

CHATWINS LIMITED.—The year has been incomparably the most difficult one experienced in recent times, both as regards Solid Fuel Appliances and Oil Heaters. Despite the adverse conditions, we were able to obtain a large proportion of the available market in solid fuel goods.

As regards the solid fuel side, we have a favourable order book, although the oil heater position has not yet got under way, this position being common to our competitors. For the future, we can be reasonably optimistic.

J. & J. WHITEHOUSE (TIPTON) LIMITED.—This Subsidiary produces cast iron holloware for export, under the name "Phœnix." The year's trading compares very favourably with the previous year, whilst the order book is quite healthy.

HALE ENAMELLERS LIMITED.—Due to the recession in the Solid Fuel Industry, the output was somewhat reduced, but at present full production is being maintained.

J. WAKEFIELD & SONS LIMITED.—We acquired this small company in December last, and should later prove beneficial to Chatwins Limited in their manufacture.

As to future prospects, I do not think there has been a more difficult period for many years now in which to prophesy what the future holds in store for industry as a whole, and more particularly for those sections of industry which are engaged in Iron and Steel. The time has arrived in the ingot steel industry when there is comparatively little backlog on order books to be pulled up. In fact, one must incline to the view that production is already exceeding demand, and this prospect directs one's mind to the extremely important part that increased exports will play in this connection. Only a Jules Verne could have predicted thirty years ago that in our time there would have been made roughly half-a-million tons of Ingot Steel each week—a marvellous performance of which the Steel Trade can be justly proud.

I am fairly certain, however, that if the low price at which sterling can be bought in foreign markets, particularly in America, keeps at its present low level, we shall have an immense advantage over our competitors in the world's markets due to the fact that our money is cheap.

The report was adopted.

SITUATIONS VACANT

CHIEF DESIGNER

A vacancy arises with a company in the North of England for a Chief Designer, to take control of an established team of specialists engaged on the design of automobile transmission equipment. Applicants must have had considerable experience in the design and production of gears and gearing assemblies for the automobile industry, and be fully conversant with the problems of mechanical power transmission. A sound technical background is essential and a Professional Degree would be an advantage. The man appointed will be required to discuss technical problems with clients up to Director level. The position offers scope for early promotion to Senior Management level, and the initial salary will be commensurate with the experience and qualifications of the selected candidate.

Applications, quoting reference C.D.1, giving all relevant details, should be addressed to BOX No. E1477, "The Engineer." A

DEVELOPMENT ENGINEER.—Venesta, Limited require a Development Engineer for their Silvertown factory which manufactures collapsible tubes and similar impact extrusions. The successful candidate should possess Higher National Certificate, have served a good engineering apprenticeship and have a flair for the design and development of automatic mechanisms. Commencing salary will be between £850 and £950 per annum.—Applications should state age, include full details of qualifications and experience and be addressed to the Personnel Manager, Venesta, Limited, North Woolwich Road, Silvertown, E.16. E9632 A

A company manufacturing Steel Racking and Shelving seeks

DEVELOPMENT ENGINEERS

Applicants should have served engineering apprenticeships, be aged 28–40, and have experience of the engineering development of projects in the industry in question or similar. There is a pension scheme in operation. Applicants should give full details of their qualifications and experience, their age and present salary.—BOX No. E1472, "The Engineer." A

DRAUGHTSMAN REQUIRED for Design Office, preferably but not necessarily with experience in the design of hydraulic presses and machines; young man with design ability and imagination preferred. A permanent post with great prospects.—BOX No. E9586, "The Engineer." A

DRAUGHTSMEN required in the following categories: Senior and Junior Piping and Instrumentation; Senior Mechanical, by Engineers in City engaged on nuclear/petroleum/chemical plants. H.N.C./O.N.C. desirable. Salaries above average. 5-day week, pension/life assurance and personal accident schemes, house purchase assistance, luncheon vouchers.—Write full particulars to Head Wrightson Processes, Ltd., 24/26, Baltic Street, E.C.1. E954 A

ENGINEER FOR COMMISSIONING AND TESTING DEPARTMENT

Candidates for this post must produce evidence that their past experience is such as will fit them to take complete charge of the commissioning of modern power plant (mechanical) and of its subsequent operation until taken over by the client.

The duties of the successful candidate, in the first place, will be abroad, but subsequently he will be attached to the London office with absences from London for periods up to six months at a time. A knowledge of testing technique as applied to boilers, turbines, cooling towers, dust collectors and auxiliary plant is desirable.

The minimum age requirement is 35 years and while good technical qualifications are highly desirable, the lack of such qualifications will not necessarily debar a candidate.

ENGINEER FOR TECHNICAL ENGINEERING DEPARTMENT

Duties are the preparation of general schemes for and detailed engineering of new thermal and nuclear energy power plants, both industrial and central, and the technical analysis of existing plants. Candidates will be expected to provide evidence that their technical and practical background is such as will enable them to assess correctly a client's plant requirements and also to determine the suitability of plant offered by a manufacturer. The work involves a knowledge of thermodynamics, fluid flow mechanics, physics and the application of these to power plant problems, for these reasons the possession of a good technical qualification in engineering is desirable. The successful candidate will be centred in London, but will be expected to undertake short visits to plant sites as required.

Applications, giving details of training, qualifications and experience to date, for the above positions, should be sent to the Personnel Officer, Ewbank and Partners Limited, 10/11, Grosvenor Place, London, S.W.1.

E9641 A

ENGINEER (MECHANICAL).—Applications are invited from Engineers, not over 35 years, who posses 1st Class M.O.T. Certificate (Steam). Willing to reside in or near London, for duties in the London area and also tours of inspections of boilers, pressure vessels, &c., in West Africa. Salary in accordance with age, previous experience, if any, plus expenses and allowances. Non-contributory pension scheme. Apply in own handwriting.—BOX No. E9483, "The Engineer." A

EXPERIENCED PRODUCTION ENGINEER AND WORKS MANAGER, age 30–40, conversant with sheet metal working and machine shop practice, capable of handling staff in small, modern and well-equipped works and willing to accept responsibility. Commencing salary £1500 per annum, plus commission. Attractive prospects.—BOX No. E1467, "The Engineer." A

EXPERIENCED DRAUGHTSMEN required for interesting design work on process plant and machinery. A good technical background and knowledge of machine design is essential and applicants should be qualified to H.N.C. standard. Salaries are assessed in accordance with age, qualifications and experience, and will be reviewed annually. Contributory superannuation and widows' pension fund are in operation and there are excellent canteen, welfare and recreational facilities. Applicants should apply in writing to the Chief Engineer, Pilkington Brothers Limited, Cowley Hill Works, St. Helens, enclosing a brief history of their career and details of their education and qualifications. E9617 A

EXPERIENCED STRUCTURAL STEELWORK DESIGNER, with a good knowledge of light structures as well as conventional steel design, required by Consulting Engineers. Five-day week.—Apply, stating full details of experience and salary required, to Alan Marshall and Partners, 73/74, High Holborn, W.C.1. E1436 A

FIRM WITH WORLD REPUTE, in Wolverhampton area, have a vacancy in their Drop Forge Department for a MANAGER.

Applicants must be conversant with modern drop forge technique and be experienced in die design and able to control labour. The situation offers excellent prospects for the right type of man, is permanent and progressive, and a good superannuation scheme is available.

Write, giving full particulars of past experience, positions held, &c., in chronological order.—BOX No. E9623, "The Engineer." A

INSTRUMENT DRAUGHTSMEN for Design, Selection, Installation and Commissioning of Modern Process Plants for a rapidly expanding Instrument Department of Chemical Division. High salaries, pension scheme. Grant towards removal expenses and living allowance until removal is effected.—Apply: Ashmore, Benson, Pease and Co., Stockton-on-Tees. E9589 A

JUNIOR INSTRUMENT DRAUGHTSMEN, having completed National Service, required for work on large chemical plant installations. A.E.S.D. minimum rates or above. Five-day week and superannuation scheme.—Apply by letter, giving details of technical education to the Chief Draughtsman, Laporte Chemicals Limited, Clifton House, Euston Road, London, N.W.1. E9355 A

KRAFT FOODS, LIMITED, of Kirkby, Nr. Liverpool, require a FOREMAN PACKAGING MECHANIC. Applicants must have had considerable experience on packaging machinery, and preferably a knowledge of margarine packaging. The post carries a good salary and there is a pension and life insurance scheme in operation. There are good prospects in this progressive and expanding company.—Please reply, with full details, including age and present salary, to Reference P.F., Personnel Department, Kraft Foods Limited, Moorgate Road, Kirkby. E1452 A

NATIONAL ESTABLISHED ENGINEERING CONSULTANTS require REINFORCED CONCRETE DESIGNER DRAUGHTSMAN. Salary and expenses £850/£950 p.a. Senior, permanent, pensionable appointment in the London area. Must be H.N.C. standard and experienced. Full personal details.—BOX No. E9638, "The Engineer." A

NATIONAL ESTABLISHED ENGINEERING CONSULTANTS offer permanent, pensionable posts for SENIOR DESIGN AND LAYOUT DRAUGHTSMEN in the London area. Salary and expenses £900/£1050 p.a., commensurate with qualifications, which should be H.N.C. or a minimum of ten years' experience in one or more of the following: Light Mechanical Precision Engineering, Small Mechanisms, Electro-Mechanical, Electrical or Electronic work. Full details.—BOX No. E9637, "The Engineer." A

NATIONAL ESTABLISHED ENGINEERING CONSULTANTS offer permanent and pensionable posts for DRAUGHTSMEN and SENIOR DESIGN DRAUGHTSMEN in the London area. Appropriate technical qualifications and experience in one or more of the following: Chemical Plant, Piping Work, Pressure Vessels, Ventilating on general mechanical plant layout. Salary and expenses £950/£1050 p.a., according to experience and qualifications. Full personal details.—BOX No. E9636, "The Engineer." A

PRODUCTION MANAGER

A vacancy exists for a Production Manager with a firm of gear and transmission specialists. The essential requirements are an extensive experience of mechanical power transmission equipment for the automobile industry, and the ability to take complete control of the production departments and to introduce new production techniques in line with modern developments. Candidates should have had experience in a similar position and a Degree in Mechanical or Production Engineering would be an advantage. The salary will be fixed in accordance with experience and qualifications.

Applications, quoting reference P.M.1, giving fullest details, should be sent to BOX No. E1478, "The Engineer." A

ROAD CONSTRUCTION MACHINERY DESIGNER REQUIRED. Experience in design of Motor Road Rollers an advantage. Good salary, pension and life insurance scheme. Apply, giving full particulars of experience and salary expected.—BOX No. E9633, "The Engineer." A

THE NESTLE COMPANY LIMITED, HAYES, MIDDLESEX, require young GRADUATES between the ages of 23–28 years, with 2nd or 3rd Class Honour or Pass Degrees in Engineering or Chemistry. Successful applicants would be given either a specific project to study under supervision, or general training on the manufacturing side, which includes milk, cocoa and coffee products and chocolate and sugar confectionery, &c. As there is a possibility that visits abroad, during training, may be necessary, a knowledge of French and/or German would be most useful but is not essential. Future Managers and Executives will be selected from the successful candidates and they must, therefore, be able to work with and direct others. Pension scheme, sports and social club, &c. Salary will be commensurate with age, qualifications and experience.—Application, with full details, should be addressed to the Personnel Officer. E1470 A

RICHARDSONS WESTGARTH (HARTLEPOOL) LTD.,

have vacancies for:—

DRAUGHTSMEN

with first-class experience for Steam Turbine and allied plant.

The posts are permanent and offer excellent prospects.

There are Pension and Life Assurance Schemes in operation.

Applications, which will be treated in strict confidence, should be addressed to the Group Personnel Officer, Richardsons, Westgarth and Co., Ltd., P.O. Box 2, Northumberland Engine Works, Wallsend-on-Tyne. E9628 A

SENIOR REINFORCED CONCRETE DESIGNERS AND DESIGNER DRAUGHTSMEN required for permanent positions on long-term development programme in East Midlands. Qualifications, H.N.C. or Graduate of Institution. Salary and expenses according to experience and qualifications. Applicants please state full personal details.—BOX No. E9639, "The Engineer." A

TECHNICAL SALES MANAGER

UNIVERSAL FURNACES LIMITED

Applications are invited for the post of Technical Sales Manager in Birmingham. The successful candidate will be required to travel over a wide area. Applicants must have experience in the field of fuel technology and be able to show a good record of sales development.

The commencing salary will be not less than £1000 per annum. The post is pensionable and the successful candidate may be required to pass a medical examination.

Applications, stating age, qualifications and experience, together with details of present and previous appointments and the names of two referees, should be addressed to the Industrial Relations Officer, West Midlands Gas Board, 6, Augustus Road, Edgbaston, Birmingham, 15 (Universal Furnaces Limited is a subsidiary of the West Midlands Gas Board).

J. SWAN,
Secretary to the Board.

E9626 A

THE SUPERHEATER COMPANY, LIMITED

53, HAYMARKET, LONDON, S.W.1.

SENIOR DRAUGHTSMEN & CHECKERS required for Power Plant Division at their London office.

Experience in Steam Boiler Plant an advantage but not essential. Permanent and pensionable positions offering good prospects for suitable applicants.—Applications are invited to the Secretary, giving full details of qualifications and experience. E9630 A

ATOMIC POWER CONSTRUCTIONS LIMITED

The above company, which is engaged in the design, construction and commissioning of Nuclear Power Stations, invites applications from Chartered Engineers for several posts.

The vacancies for which applicants are now being considered are as SITE RESIDENT ENGINEER to supervise the construction of complete power stations, and for MECHANICAL, ELECTRICAL and CIVIL ENGINEERS to act as assistants to the Site Engineer.

Vacancies also exist for SITE COMMISSIONING ENGINEER and MECHANICAL and ELECTRICAL ASSISTANTS.

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The Secretary (Ref. JNB),
Atomic Power Constructions Ltd.,
28, Theobalds Road,
London, W.C.1. E9635 A

SHOP FOREMAN

required for Rolling Mill on Tyneside

The plant concerned is producing brass and copper sheet and strip, and applicants must be fully conversant with modern rolling mill practice, and preferably have had some experience in a supervisory capacity on this type of work.

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OPPORTUNITY FOR A WELL-EDUCATED YOUNG MAN

(about 35), with an engineering background, administrative and preferably sales experience, to join a public company of repute who are looking for someone to take over a Managerial post within the next two years. Energy, enthusiasm and initiative essential.

Good starting salary and excellent prospects. Bonus and pension schemes. Full details in writing.—BOX No. E9547, "The Engineer." A

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From 20 years of age. G.C.E. essential. High standard of printing and neatness of layout required. Experience in graphical and cartographical preparation; Technical diagram layouts and preparing machine shop drawings from rough sketches. Salary not less than A.E.S.D. Minimum Rates.

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E9618 A

ENGLISH ELECTRIC COMPANY LIMITED

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DRAUGHTSMEN AND DESIGNERS

Following the announcement of contracts for the introduction of the THUNDERBIRD missile into service with the R.A.F. and the Army, there is an increasing demand for Draughtsmen and Designers at both our Luton and Stevenage establishments.

Applications are invited for positions in our electronic, servomechanism and instrument departments from electronic, electrical and mechanical draughtsmen who have had at least two years' relevant draughting experience and who have served an engineering apprenticeship and obtained an Ordinary National Certificate.

For some of the more senior vacancies about seven years' experience is essential. The company operates a comprehensive pension scheme.

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A SHORT INTENSIVE COURSE

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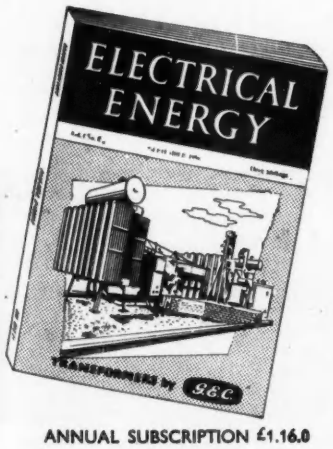

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CASH PAID.
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HIGH-CLASS LATHES IN STOCK

REED PRENTICE 14in. Model "AA," S.S. and S.C. Lathe, motor drive, straight bee ved, leadscrew, feed and clutch shaft, Norton type gearbox, Timken roller bearings, taper turning attachment, swing over bedways 16½in., swing over carriage 10½in., distance between centres 30in., 16 spindle speeds from 18–536 r.p.m., hole through spindle 1 9/16in.

LE BLOND 17in., Super Regal motor drive, all-gear selective type headstock, with special rapid speed selector, height of centres 8½in., distance between centres 42in., swing over saddle 10½in., swing in gap 24in., width of gap in front of spindle 6½in., 8 spindle speeds 20–425 r.p.m.

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LANG 30in. swing, heavy duty, motor drive, all-geared headstock, two saddles, one with hexagon turret, swing over bed 30in., swing over saddle 19in., distance between centres 15ft., 12 spindle speeds 1·6–95 r.p.m., h.p. motor 20.

SCHIESS-DEFRIES Super-Express Lathe, Type YDE, 15¾in. height of centres, between centres 10ft., with automatic controller, speed range from 20–600 r.p.m., swing over bed 34½in., swing over saddle 22in.

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HARVEY 32in. Break Drum Lathe, with sliding bed, D.C. motor drive and variable-speed headstock, swing in gap 9ft., swing over bed 65in., swing over saddle 51in., admits between centres (gap fully opened) 25ft., speed range 0·75–38·5 r.p.m.

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E210 G

600

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3000kW., 6600/3/50, MET.-VICK., Pass-Out/Condensing Steam Turbo-Alternator Set, date 1948, designed for 340 p.s.i.g. initially, 600 deg. F. temperature ; also suitable for the following duties :—

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Classified Advts. continued on page 6

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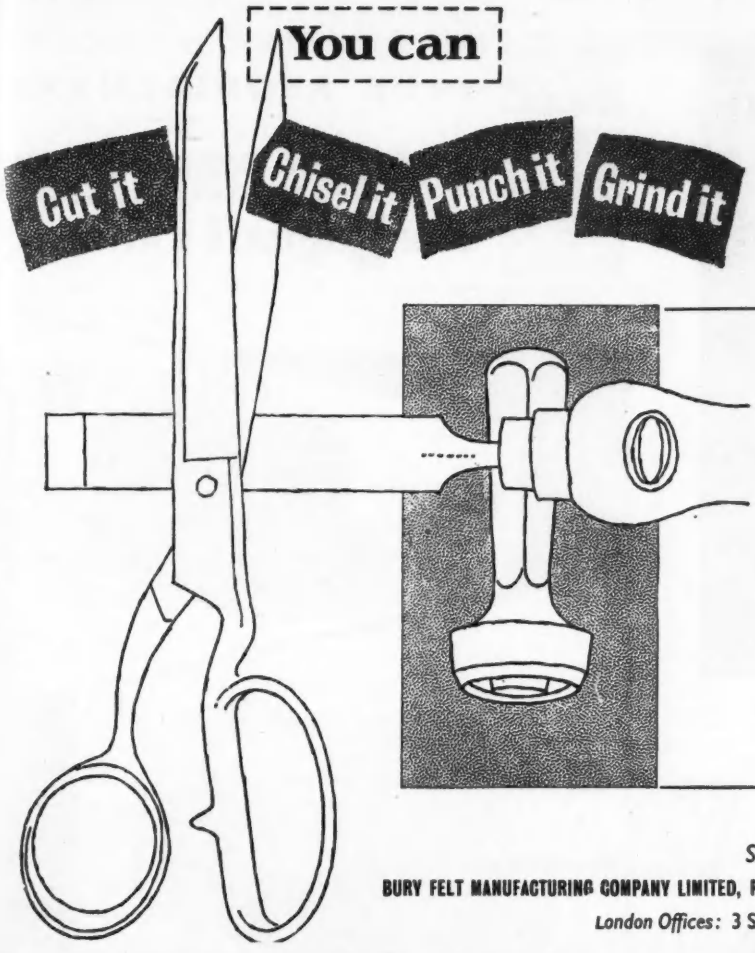

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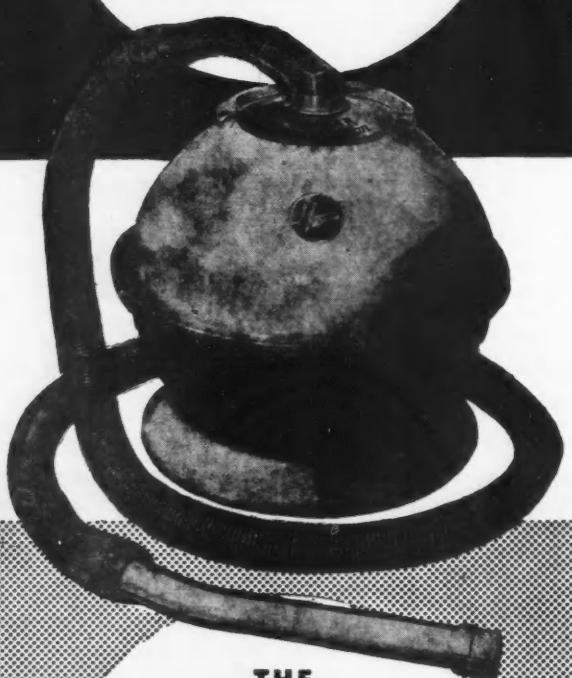

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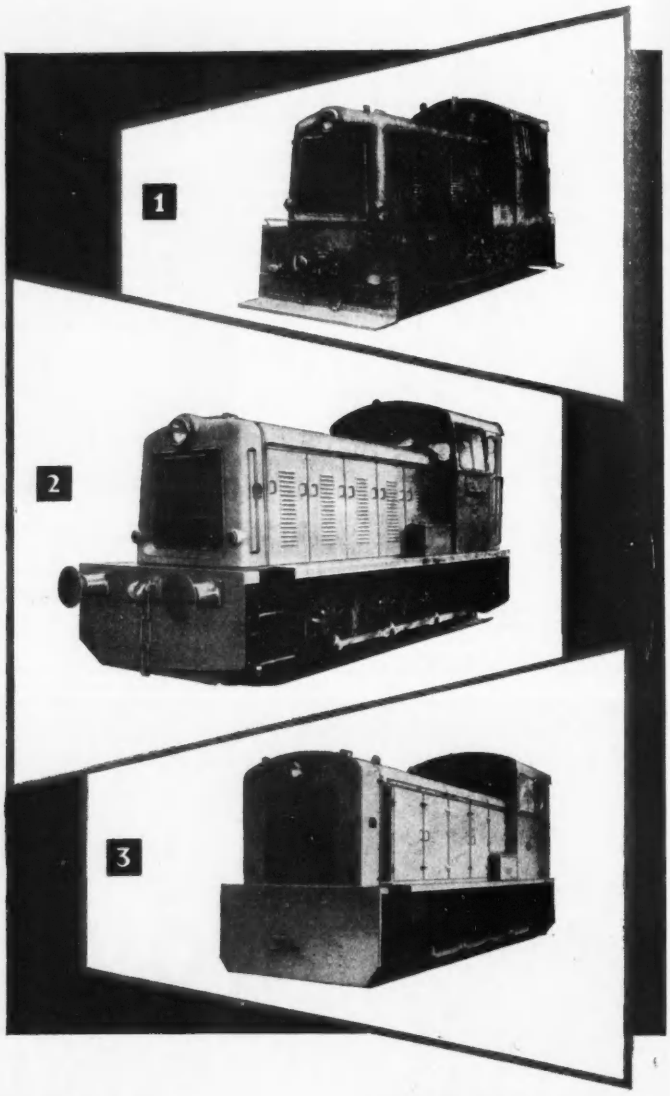

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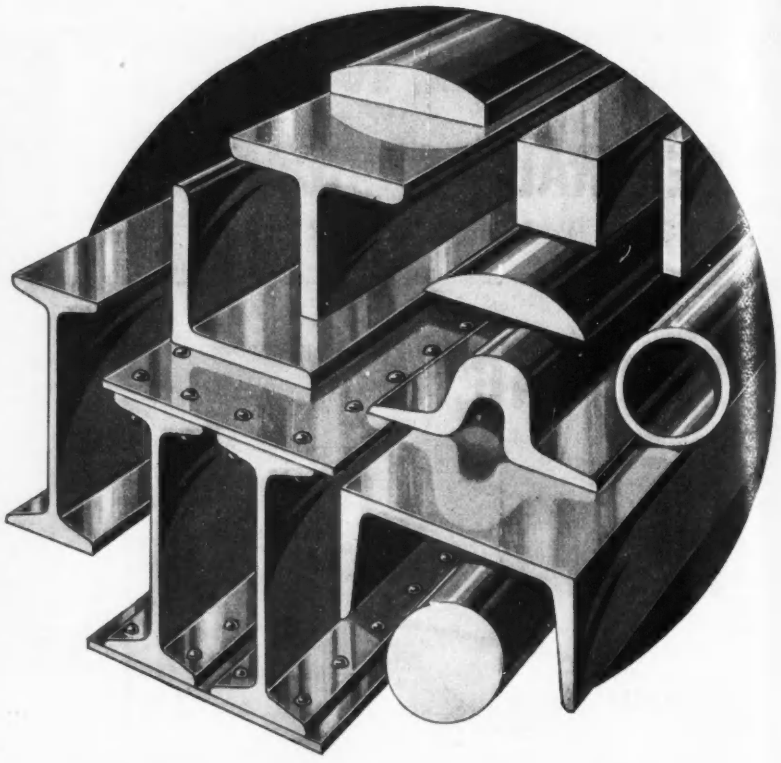

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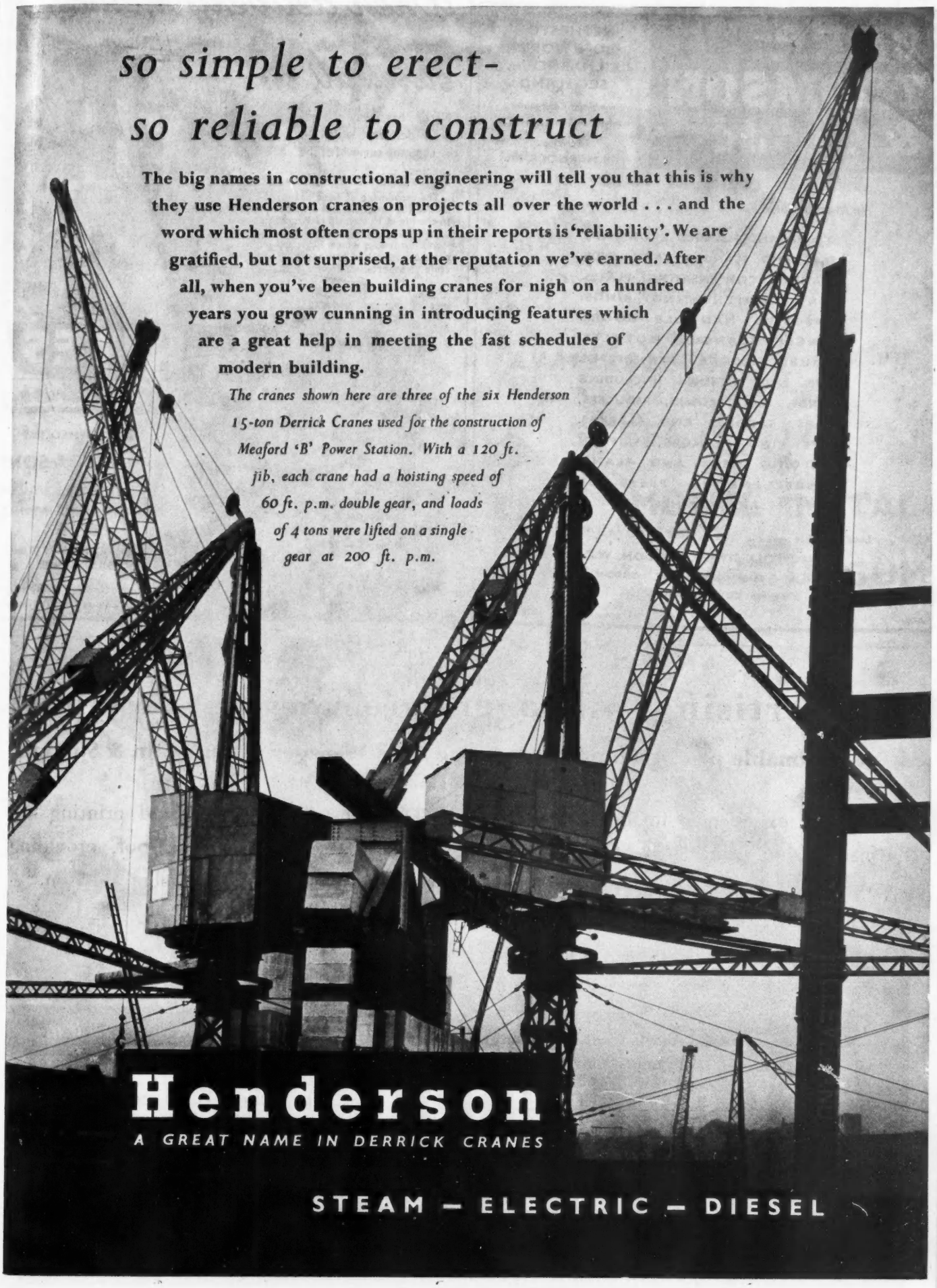

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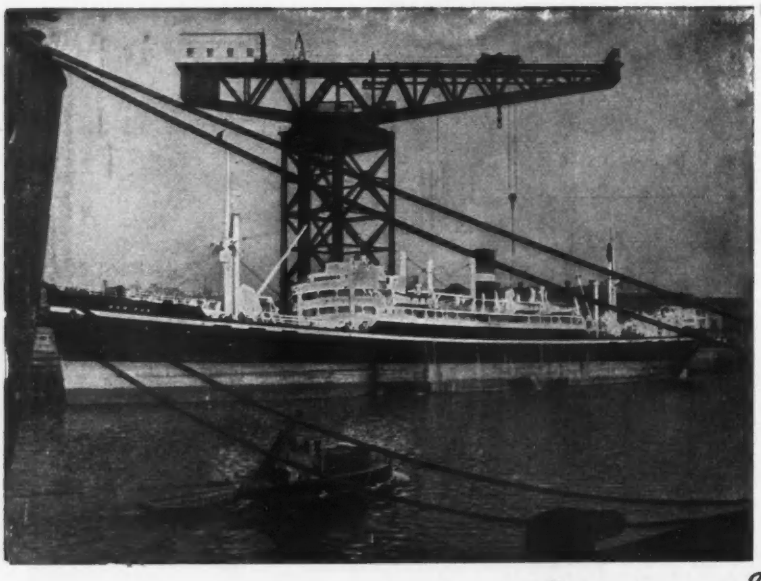

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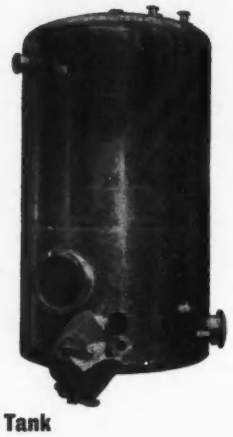

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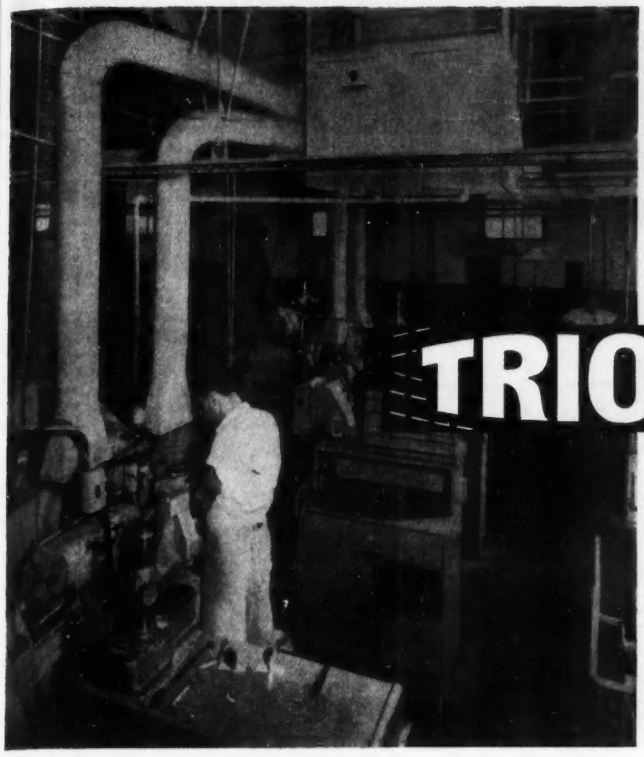

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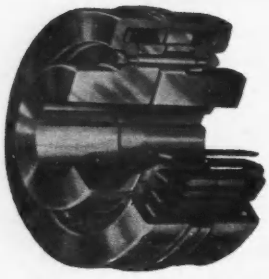

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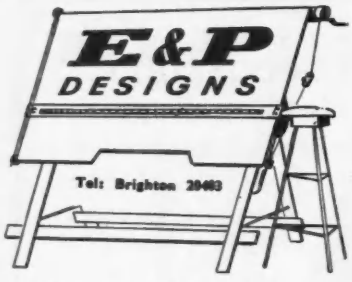

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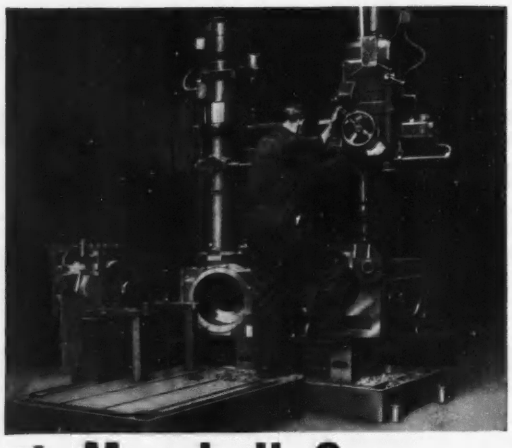

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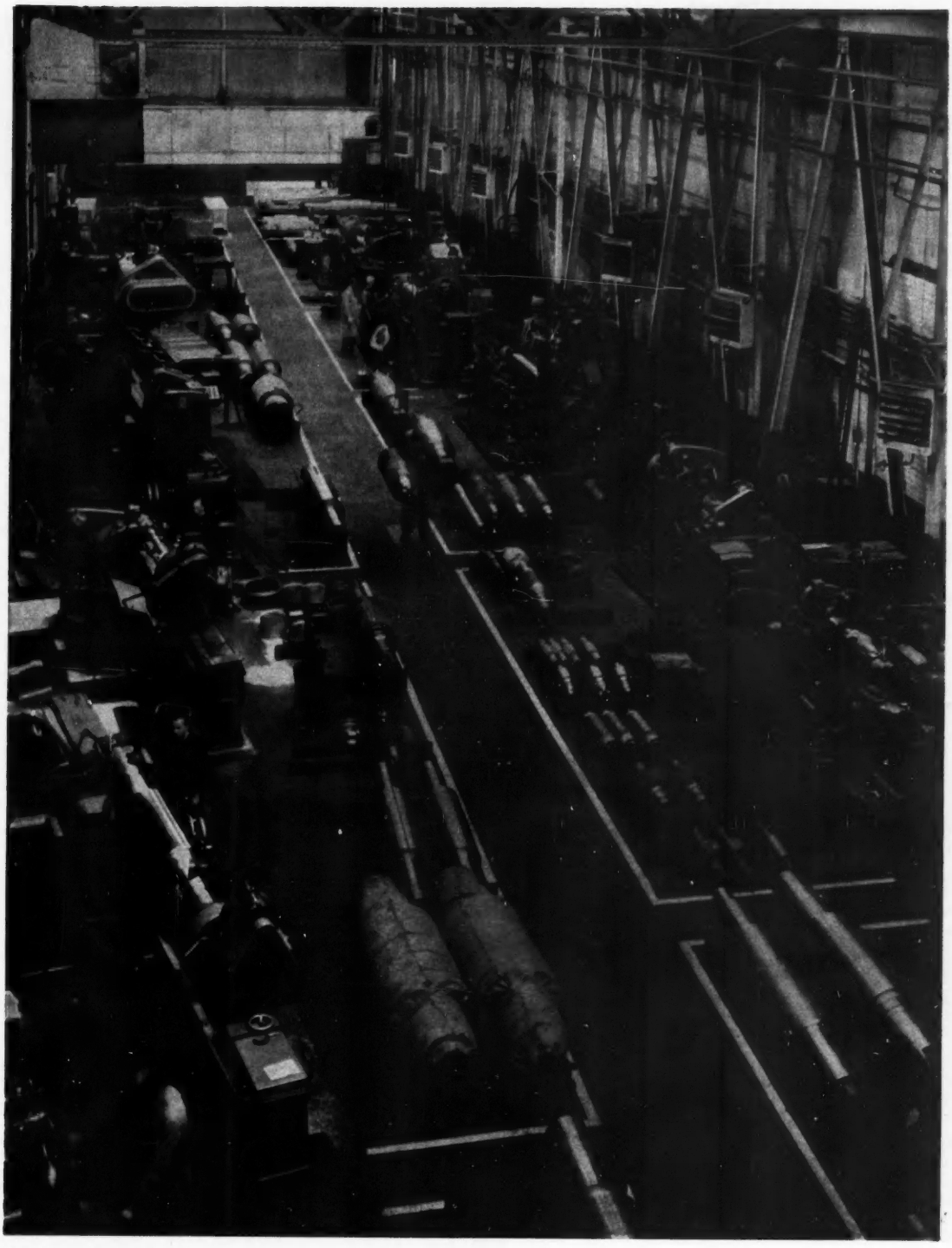

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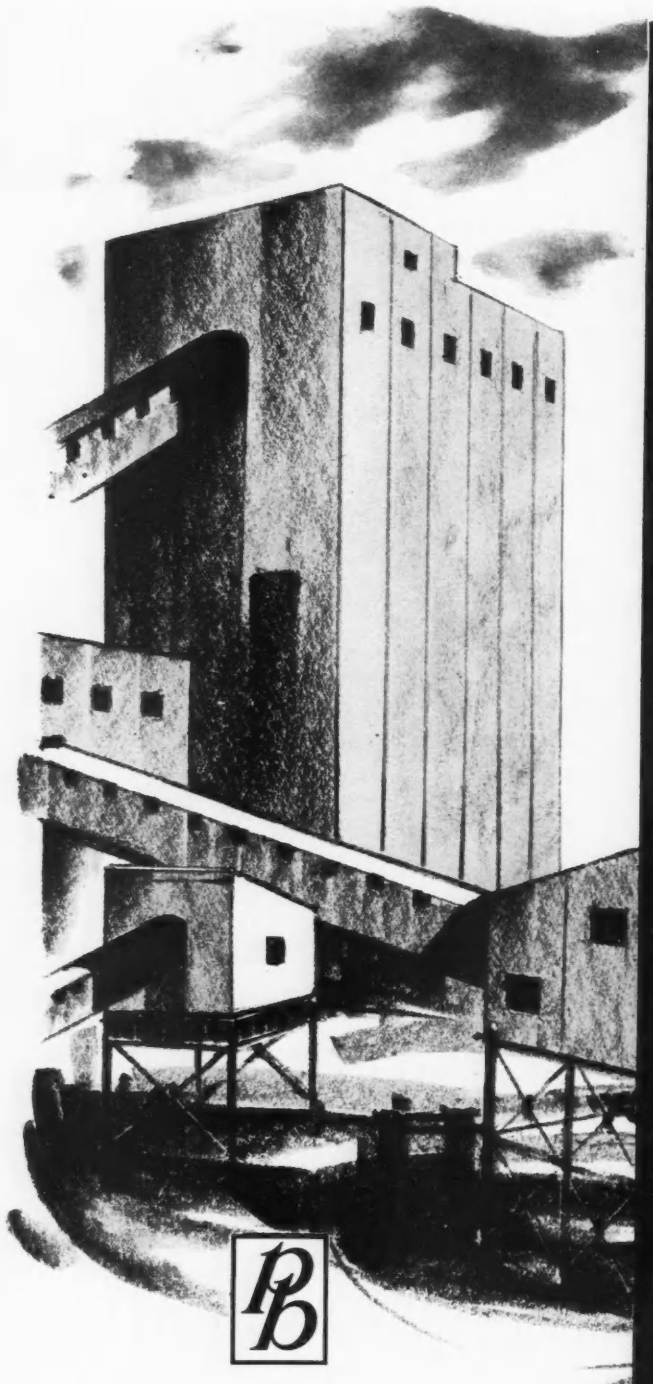

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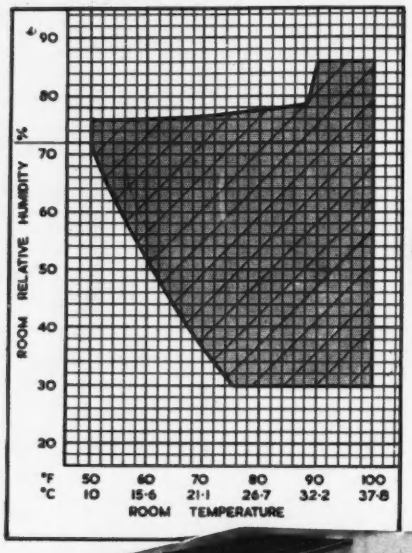

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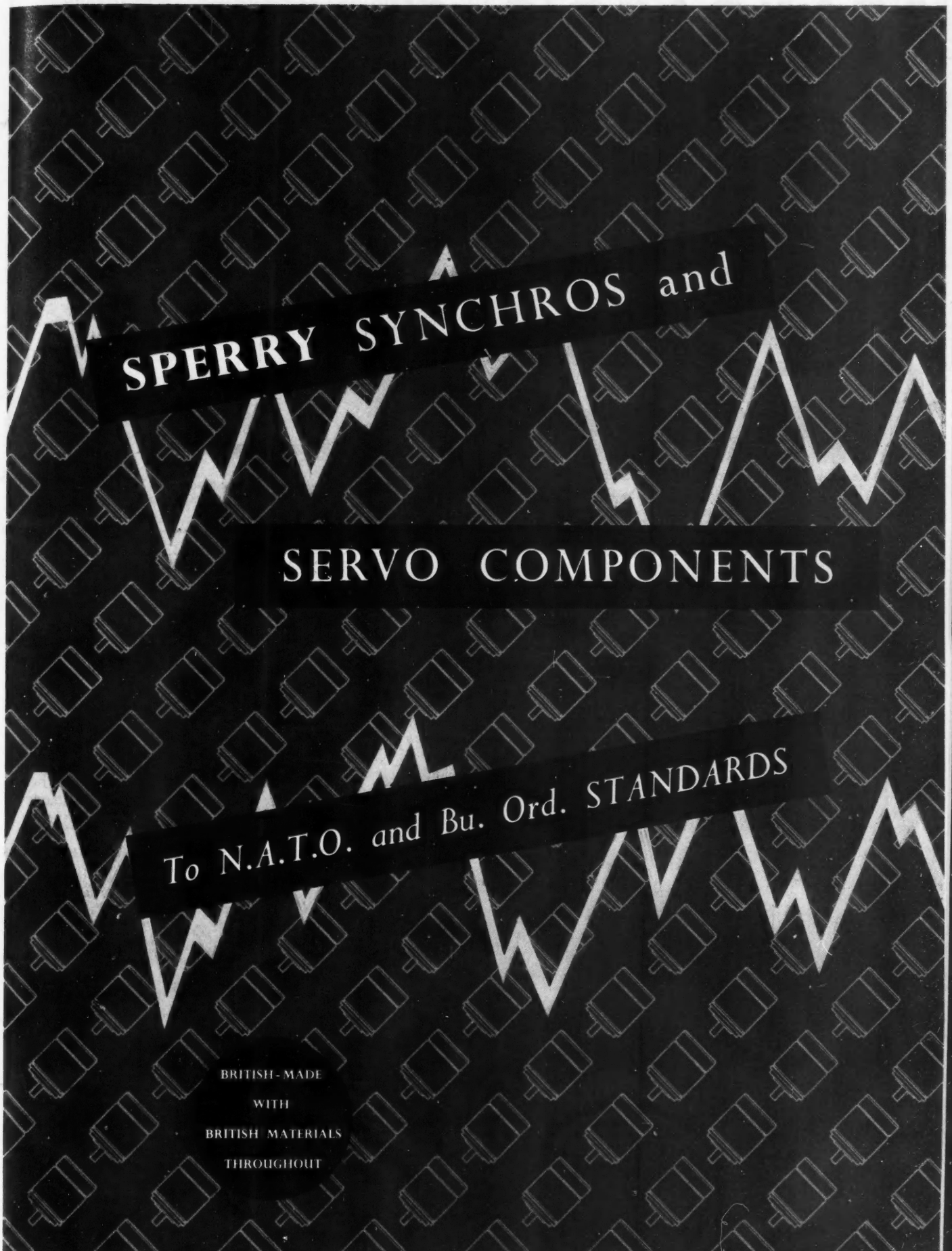

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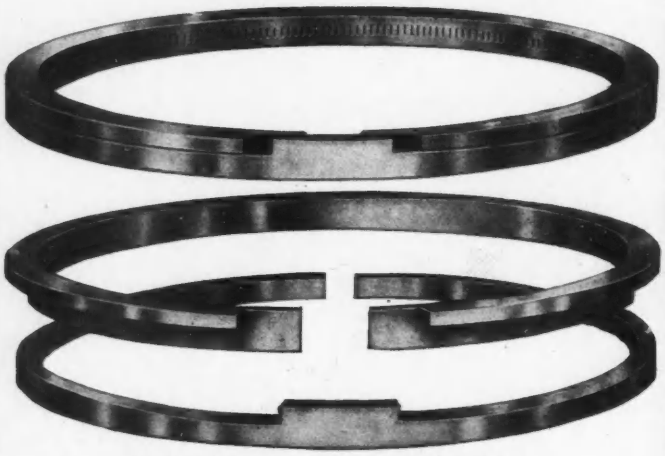

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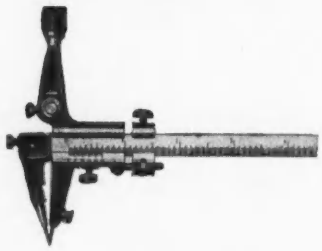

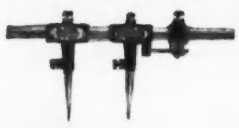

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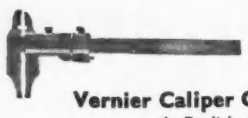

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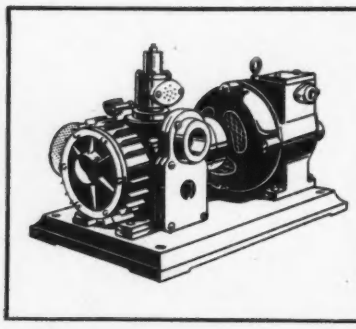

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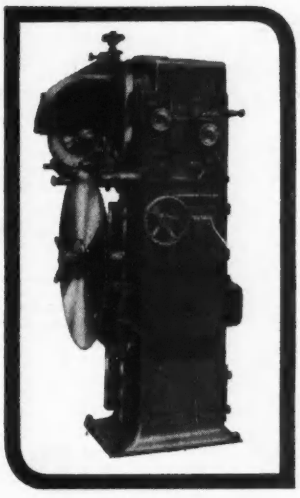

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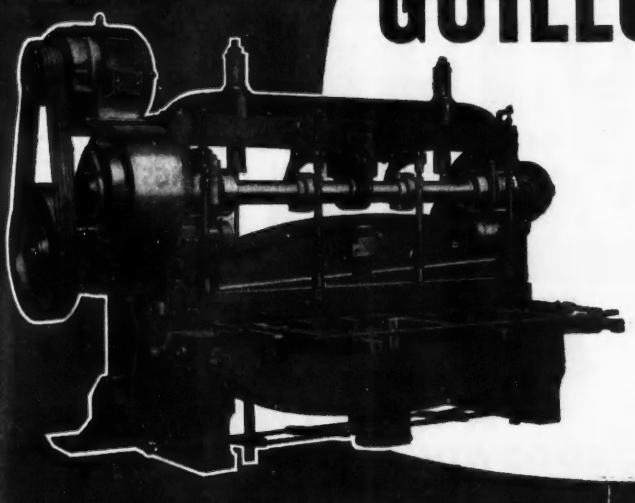

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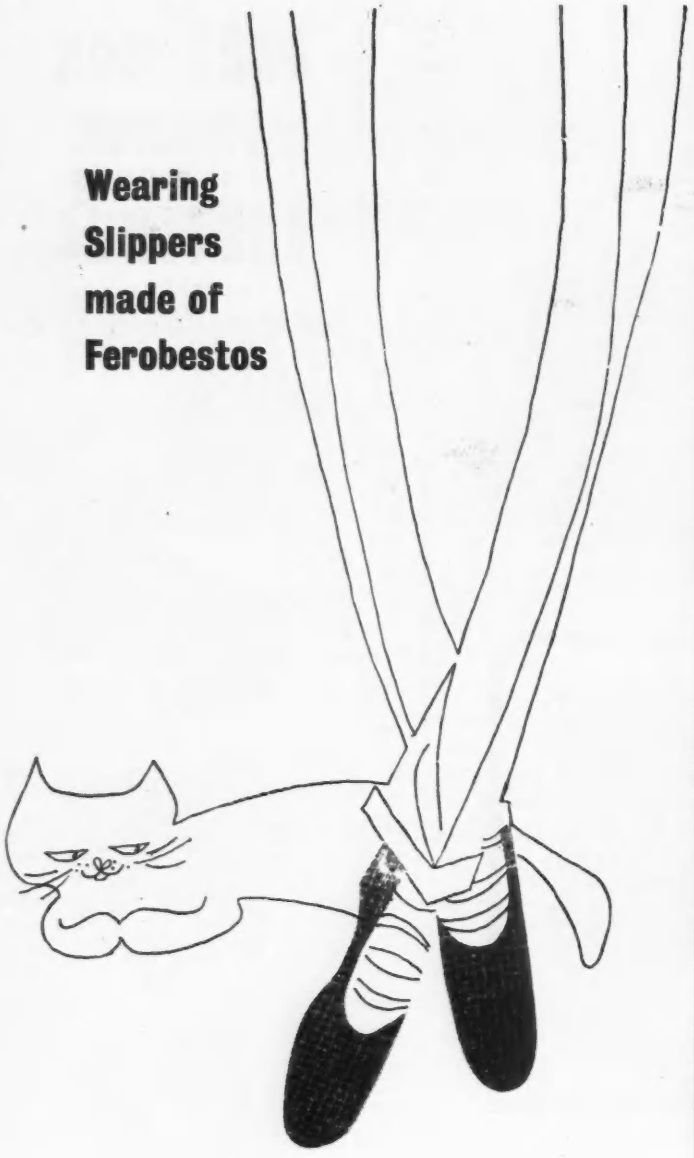

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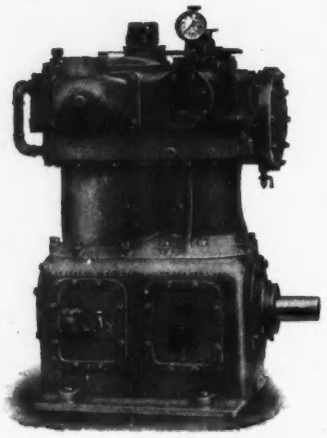

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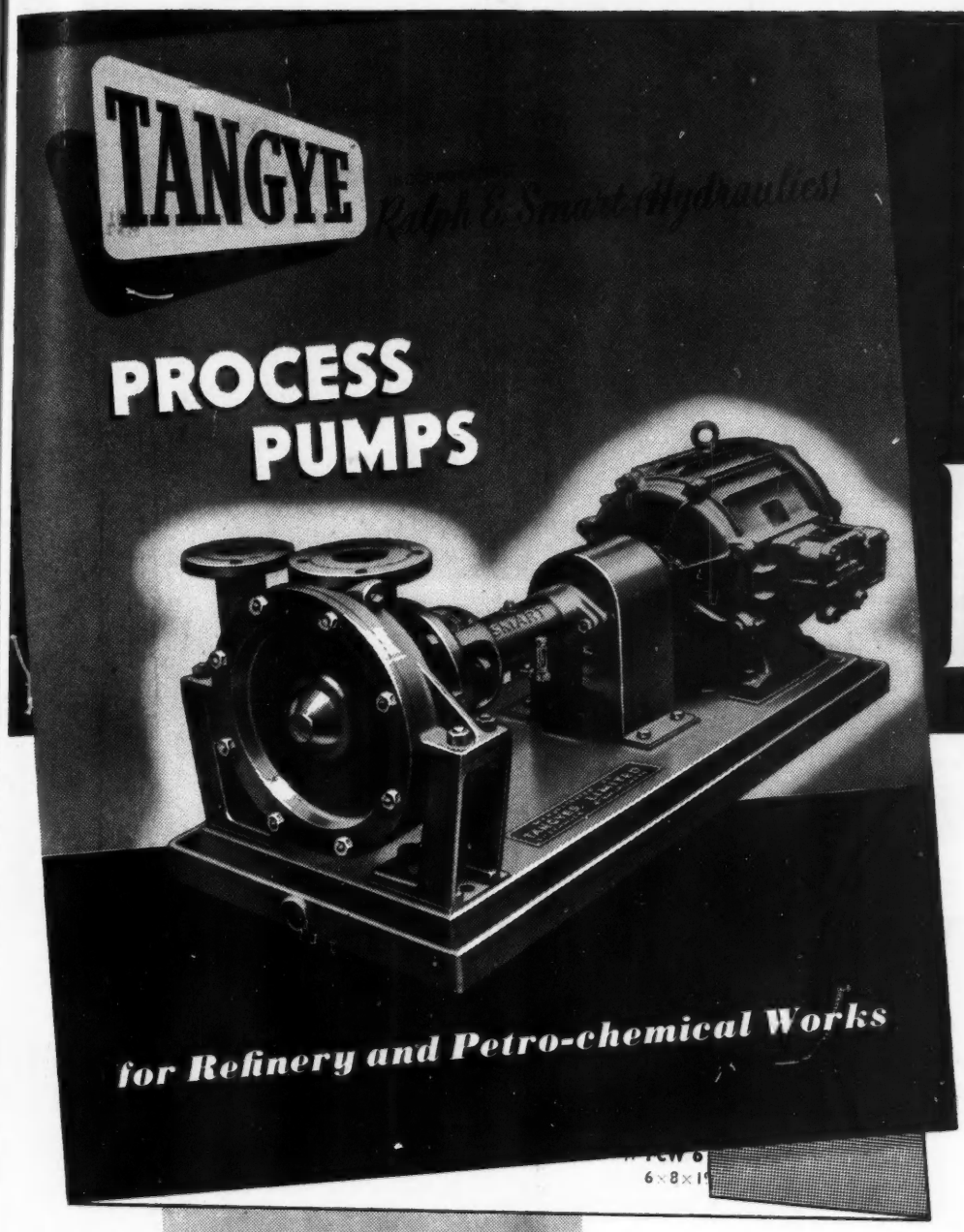

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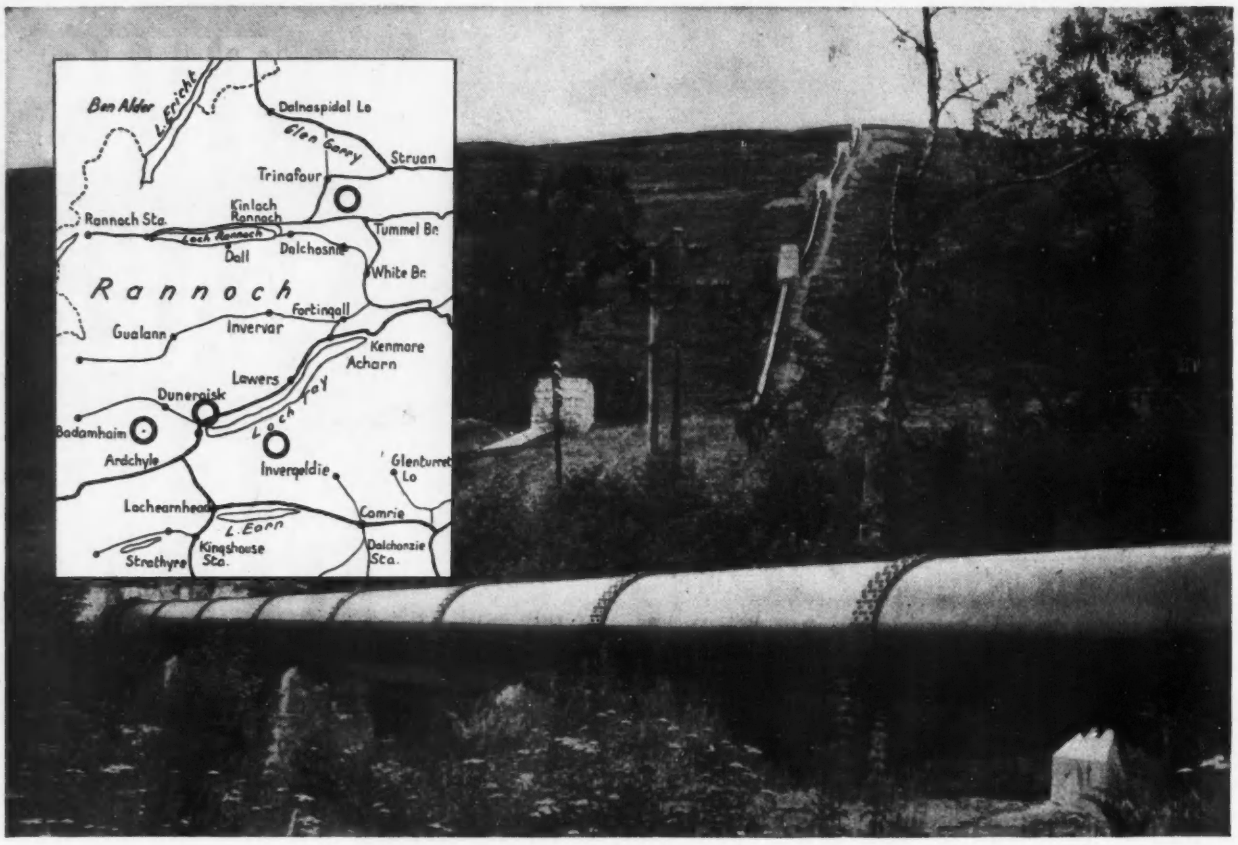

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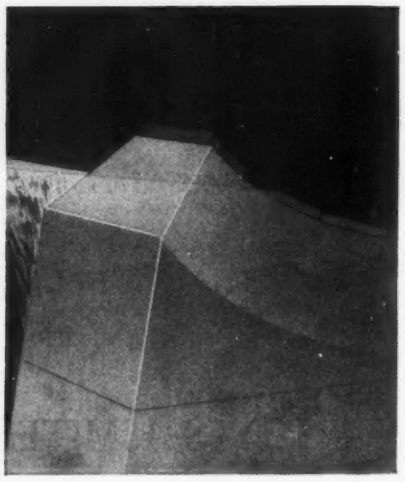

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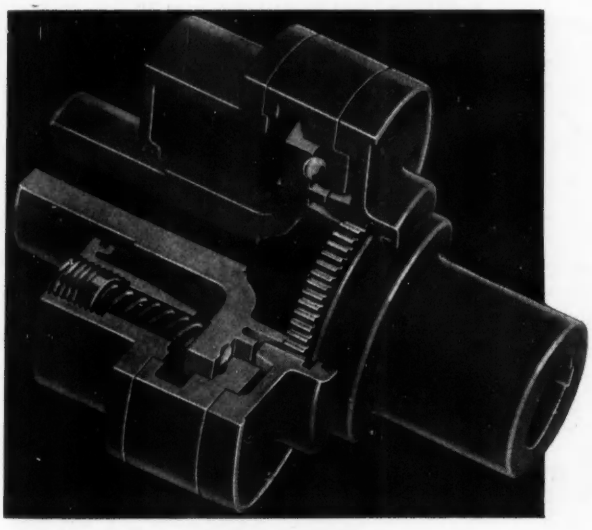

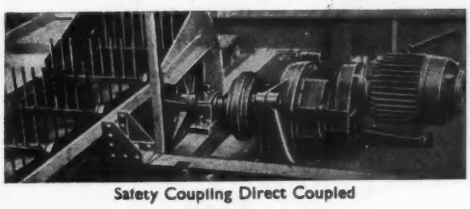

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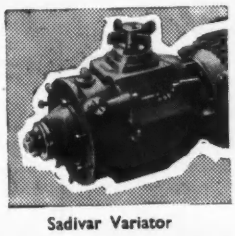

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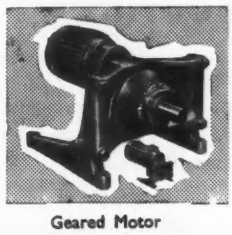

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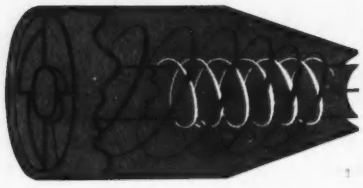

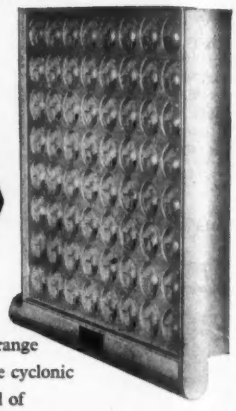

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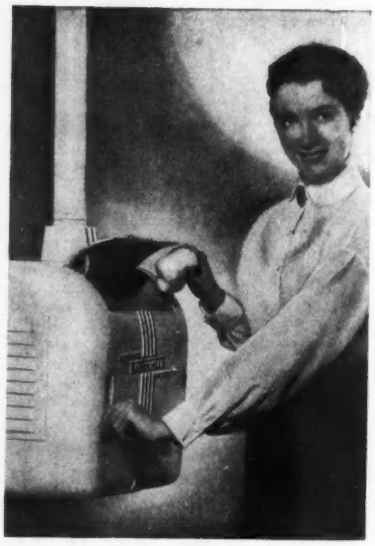

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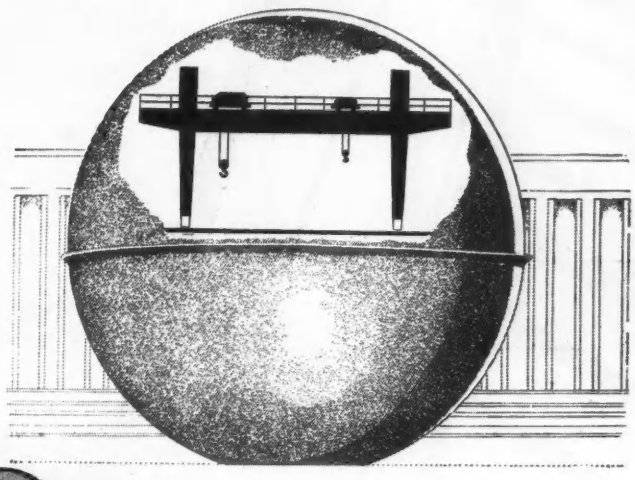

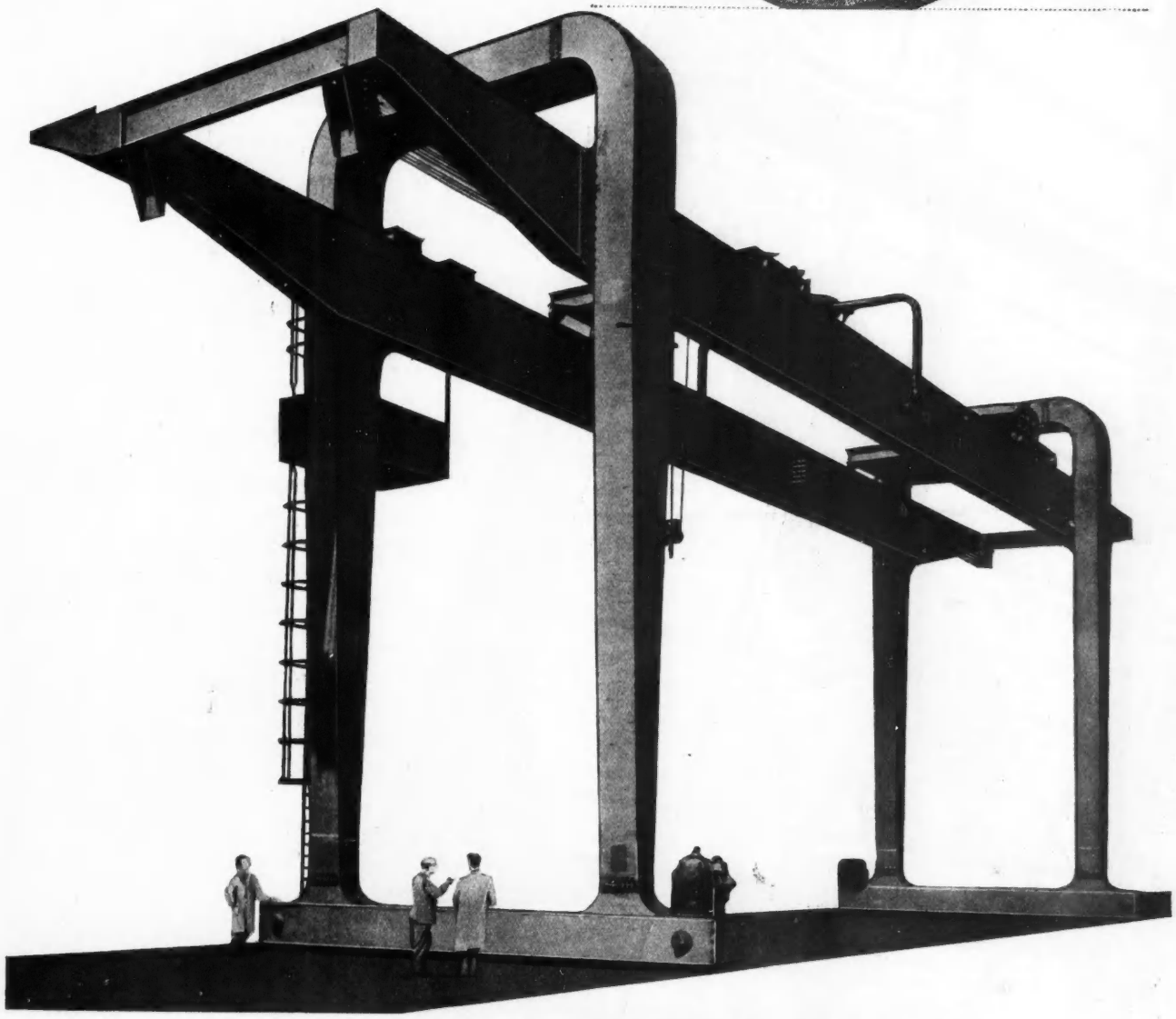

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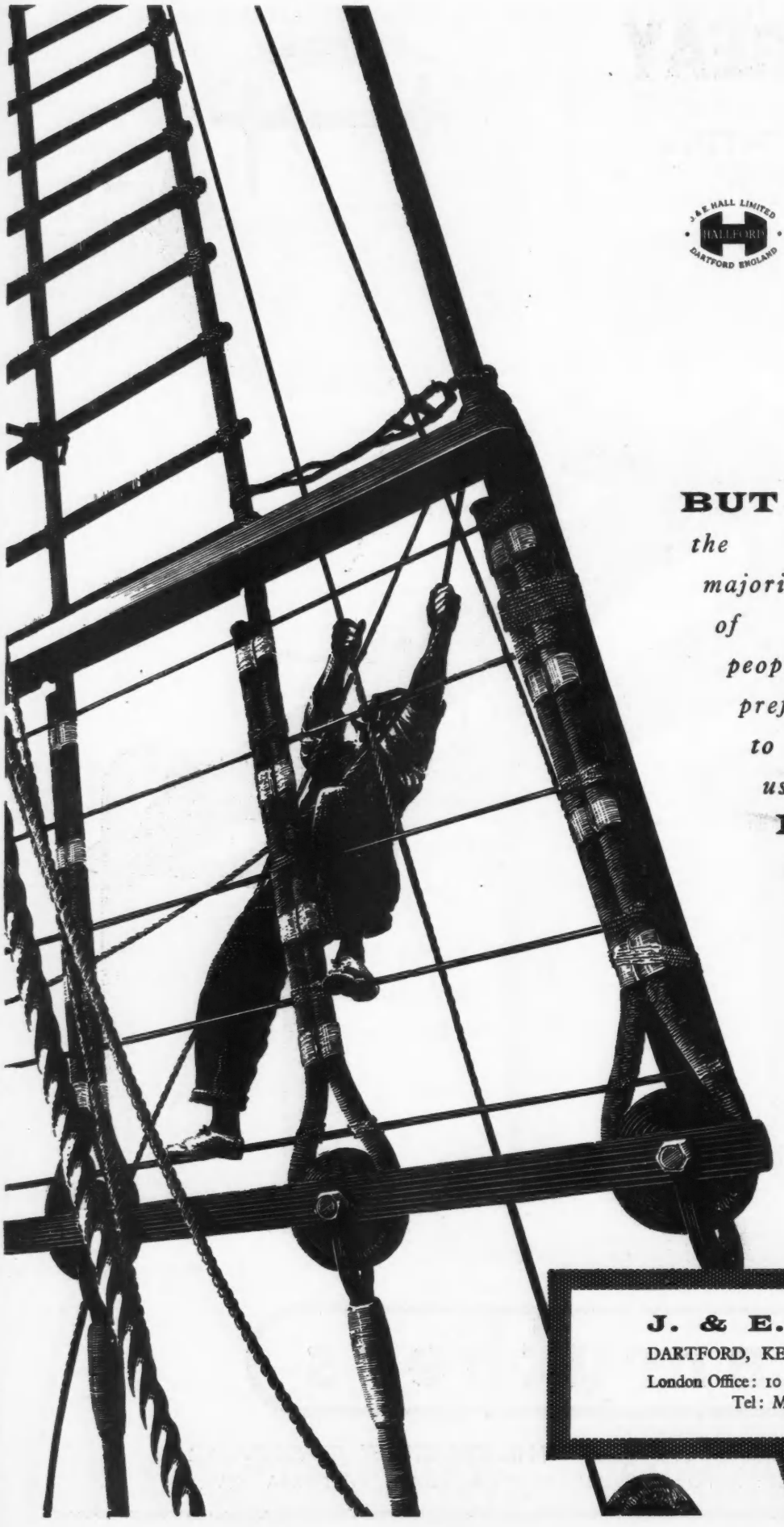

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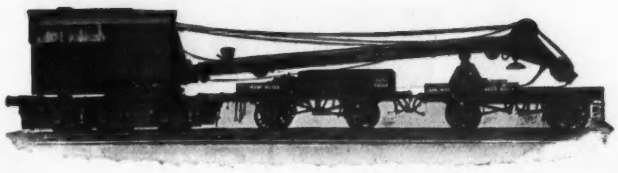

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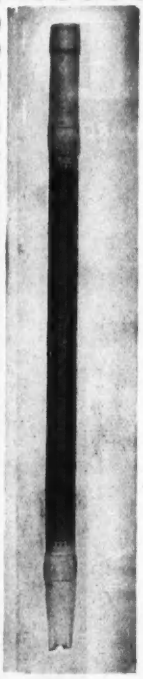

Fig. 188

Fig. 182. DW6 Diesel Driven Dewatering Pump.

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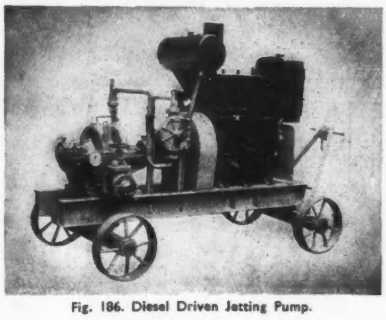
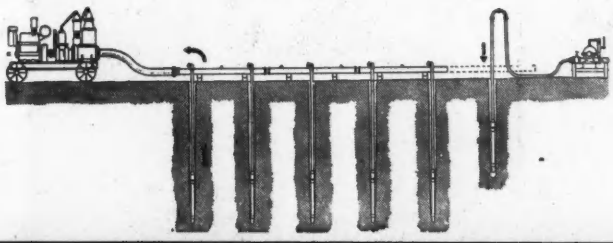


Fig. 186. Diesel Driven Jetting Pump.



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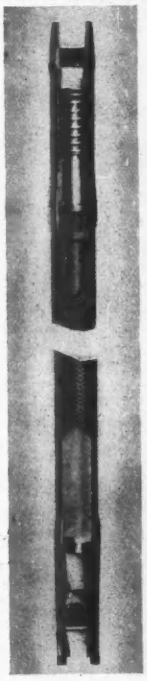

Fig. 188B

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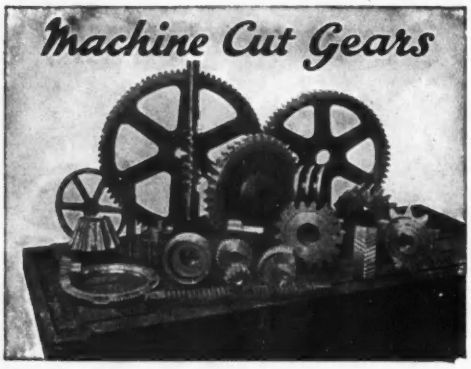

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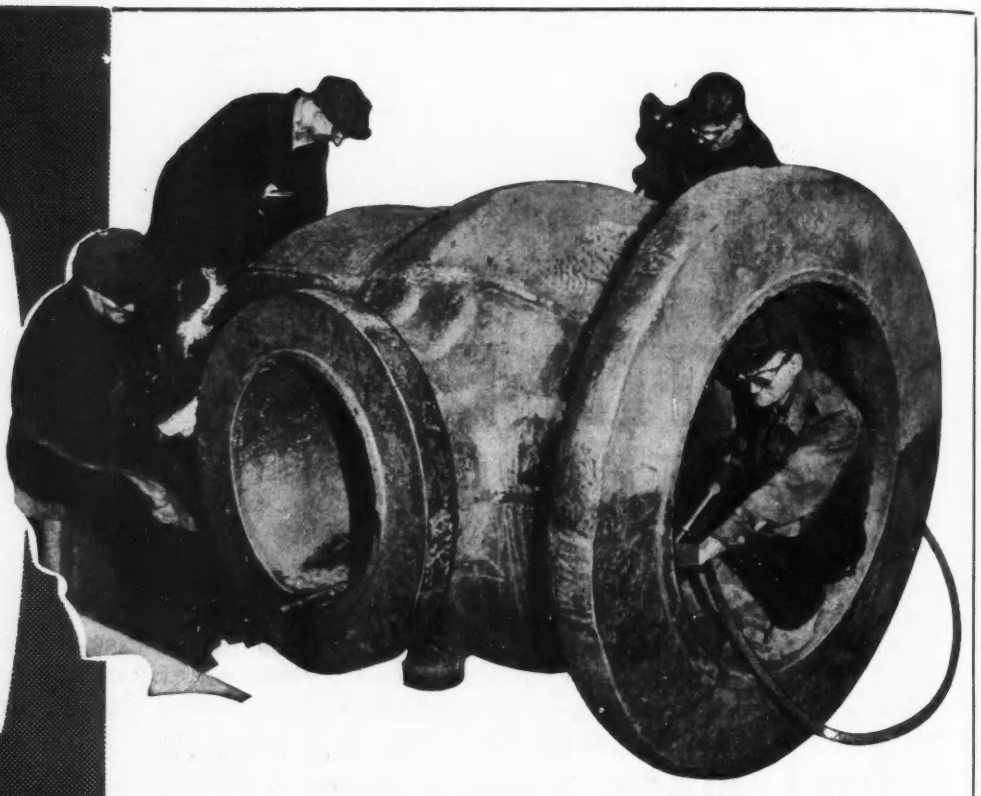

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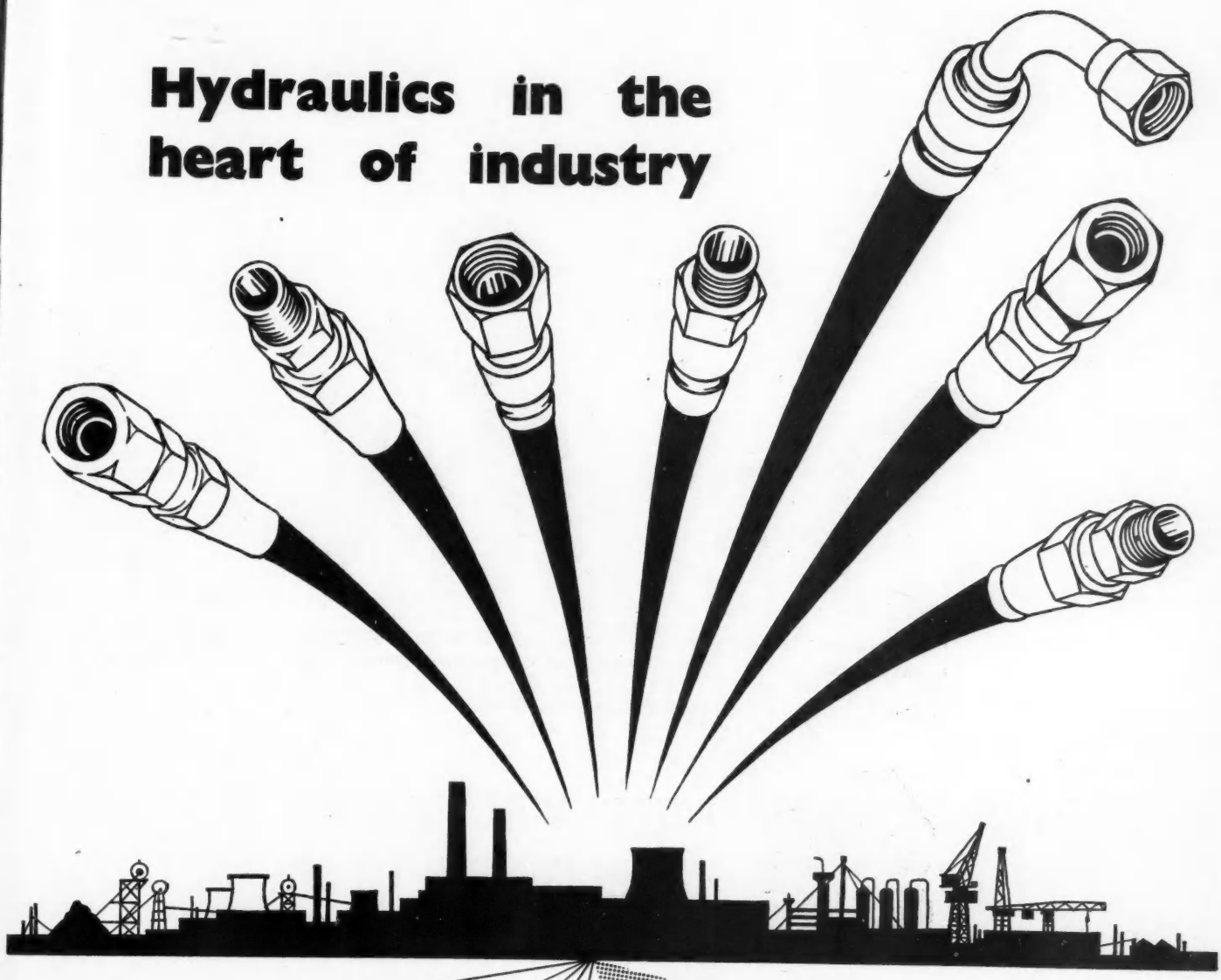

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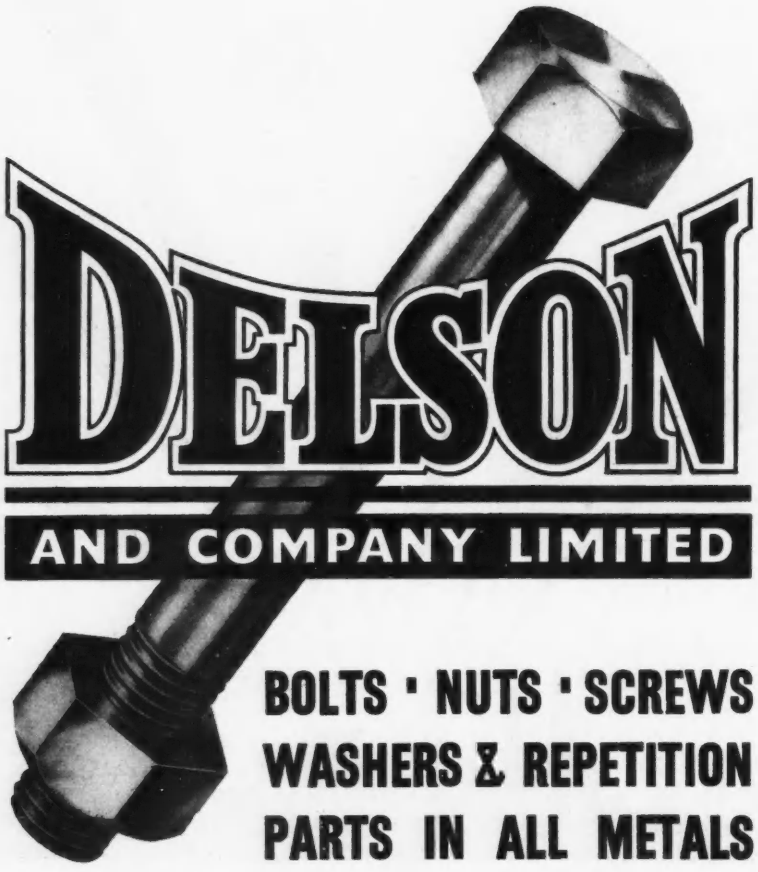

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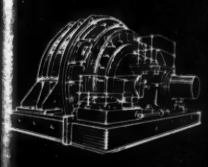

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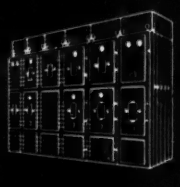

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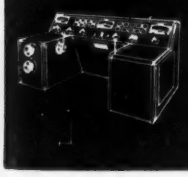

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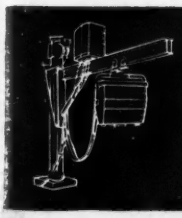

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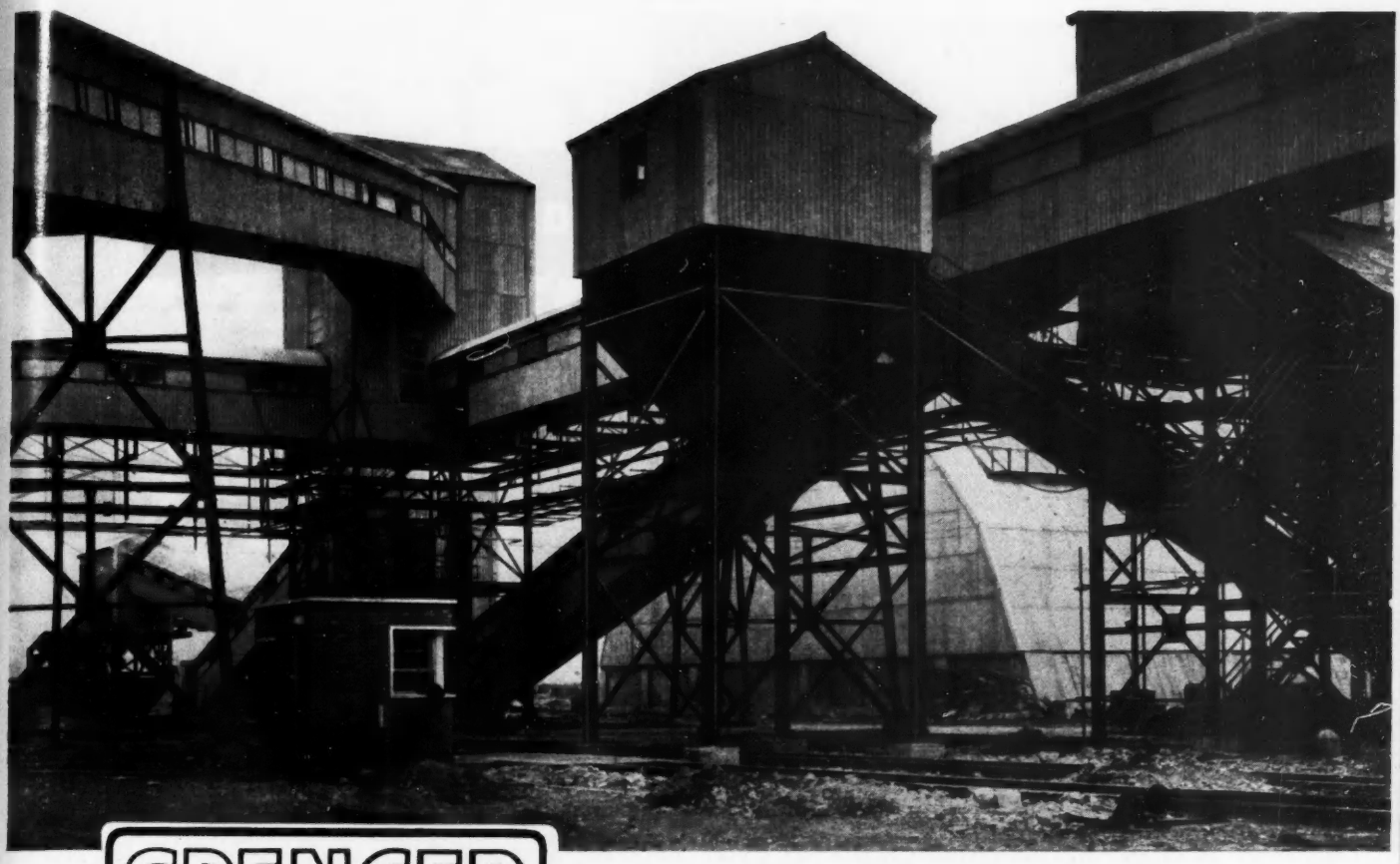

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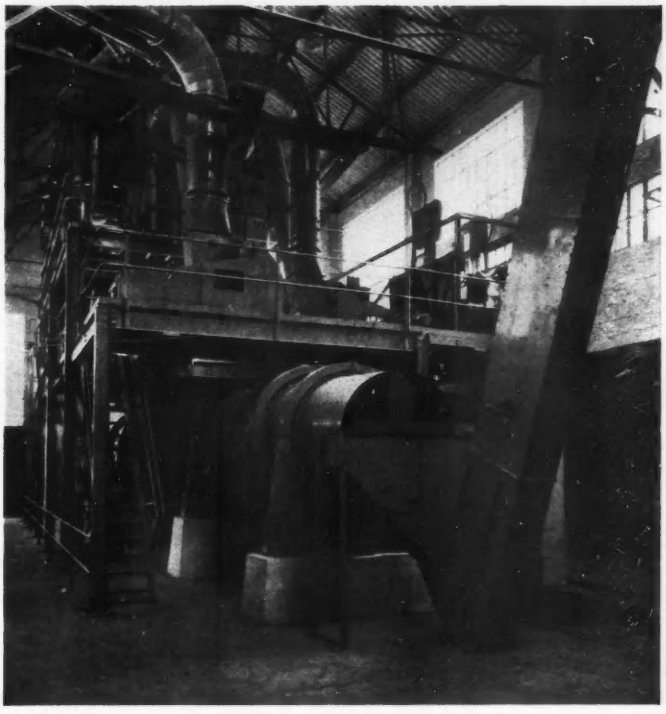

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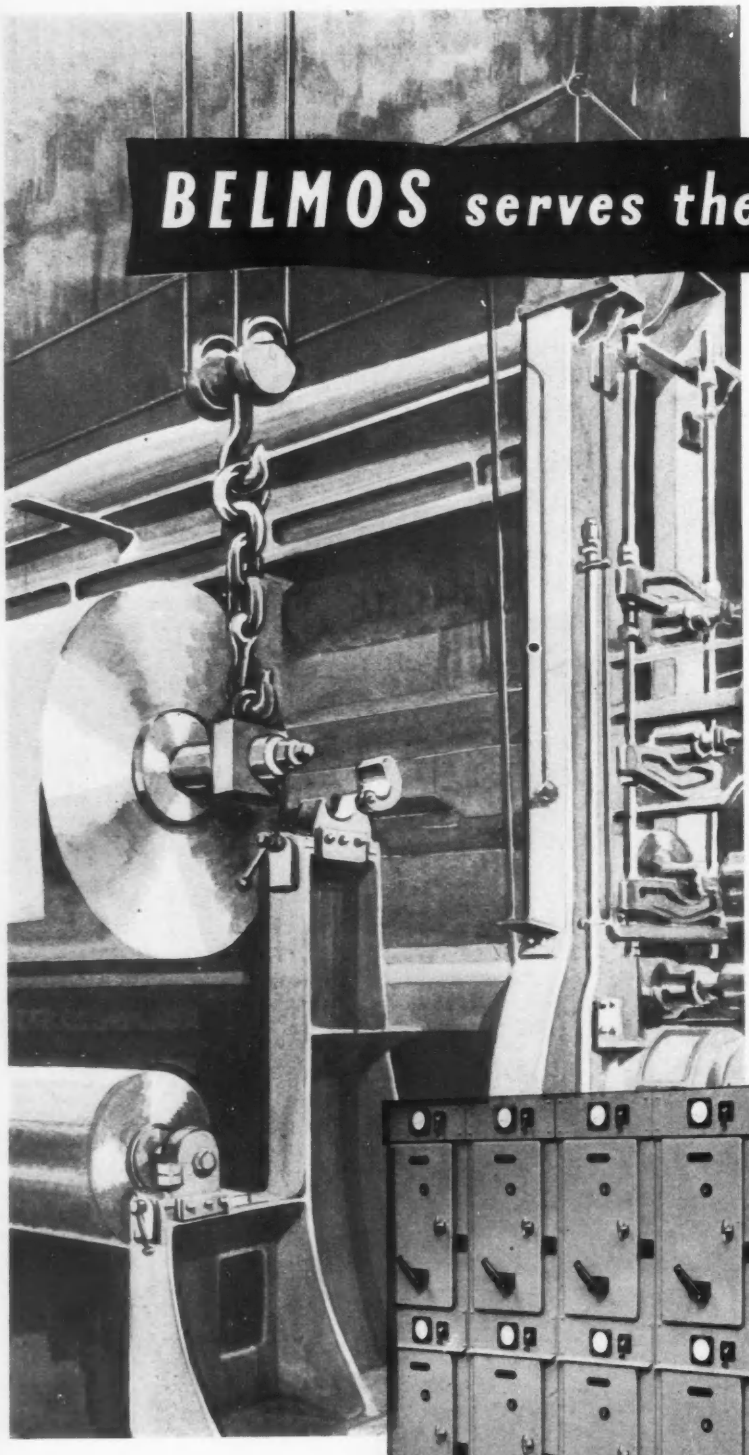

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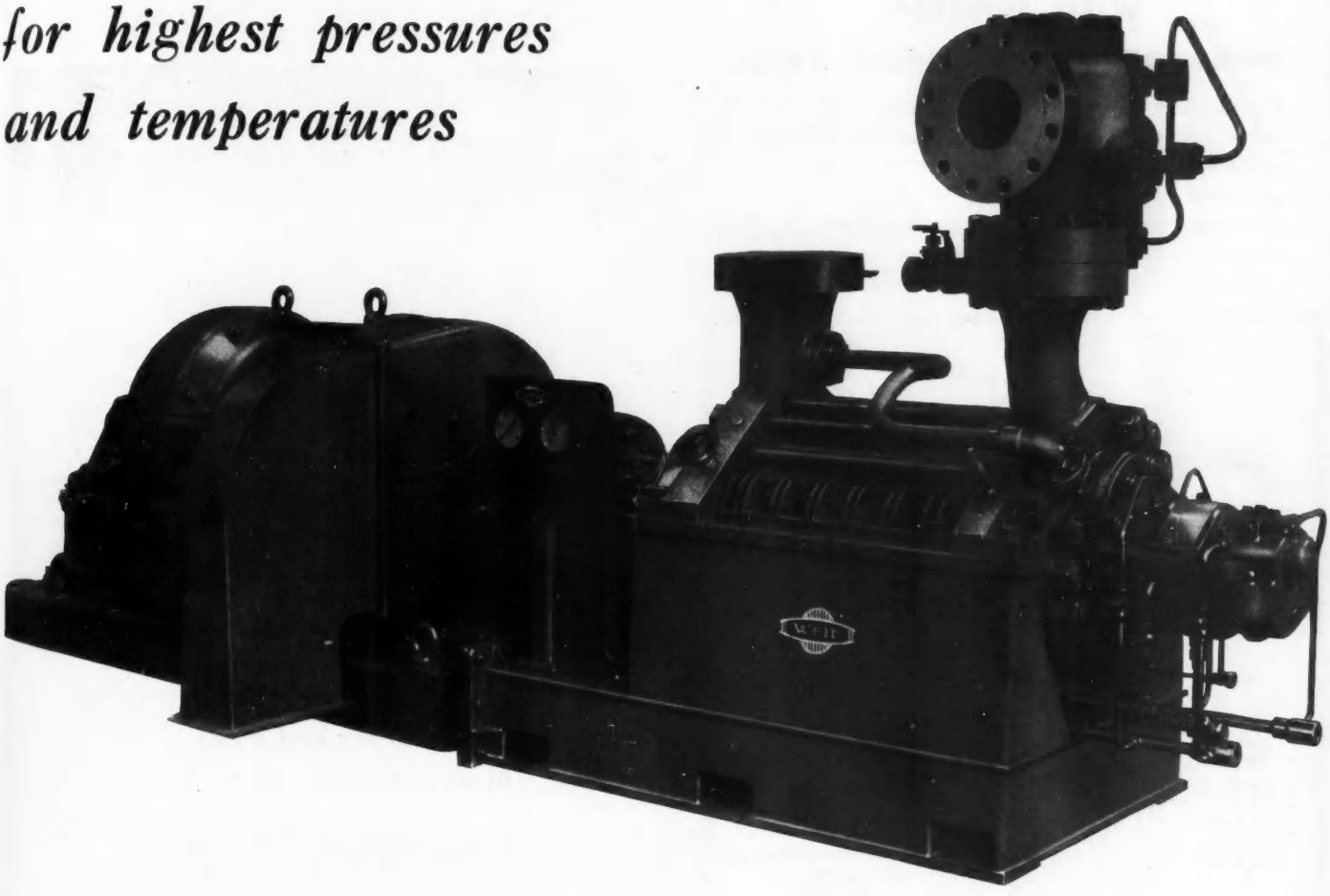

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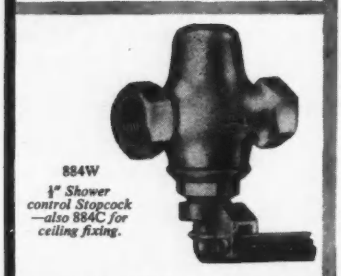

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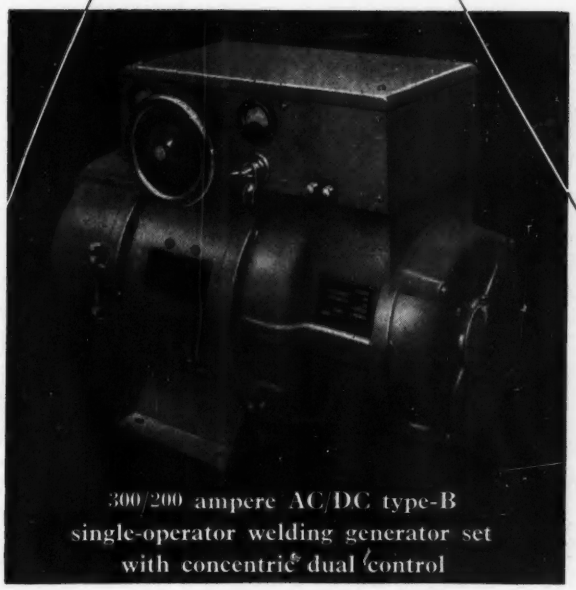

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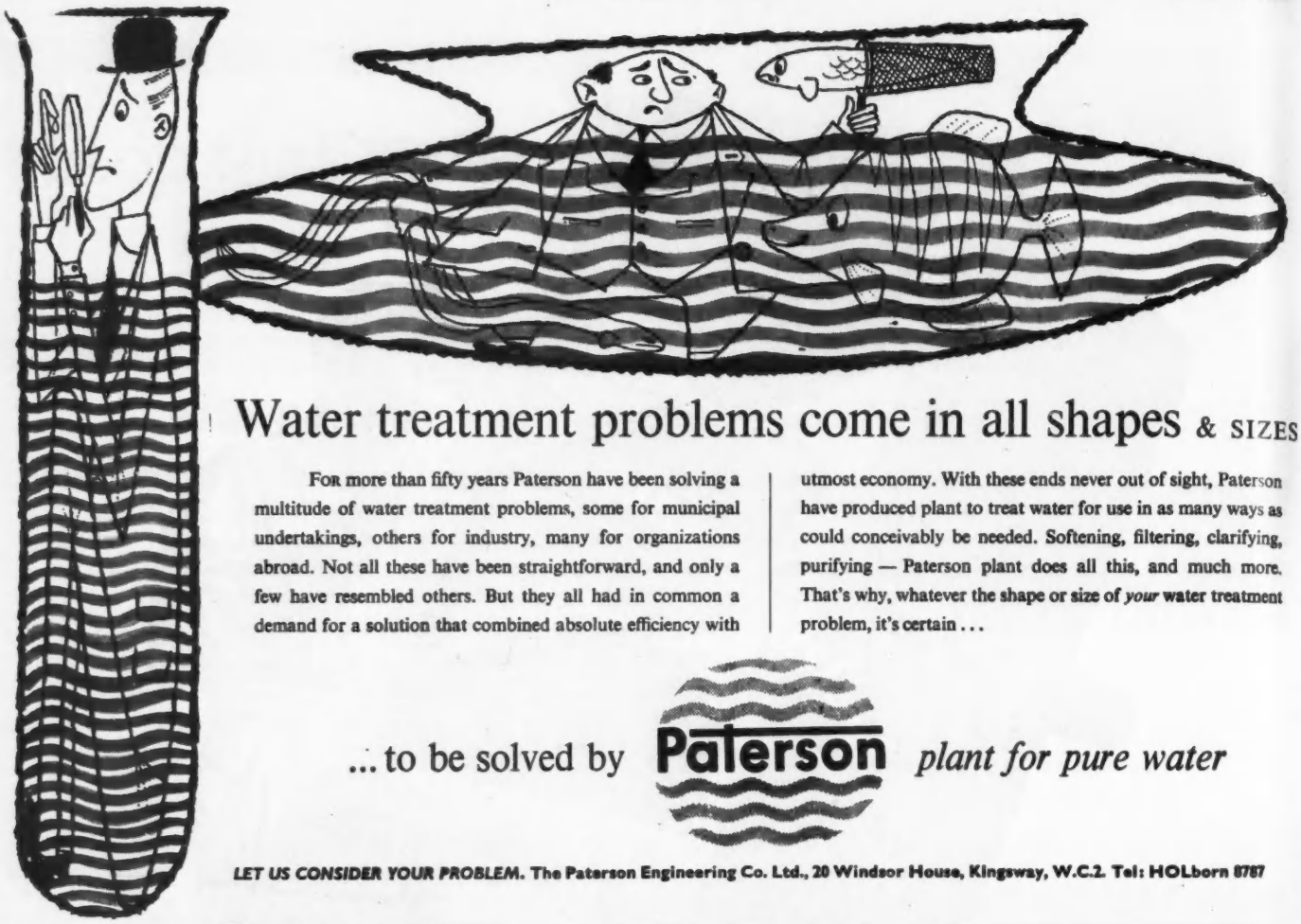

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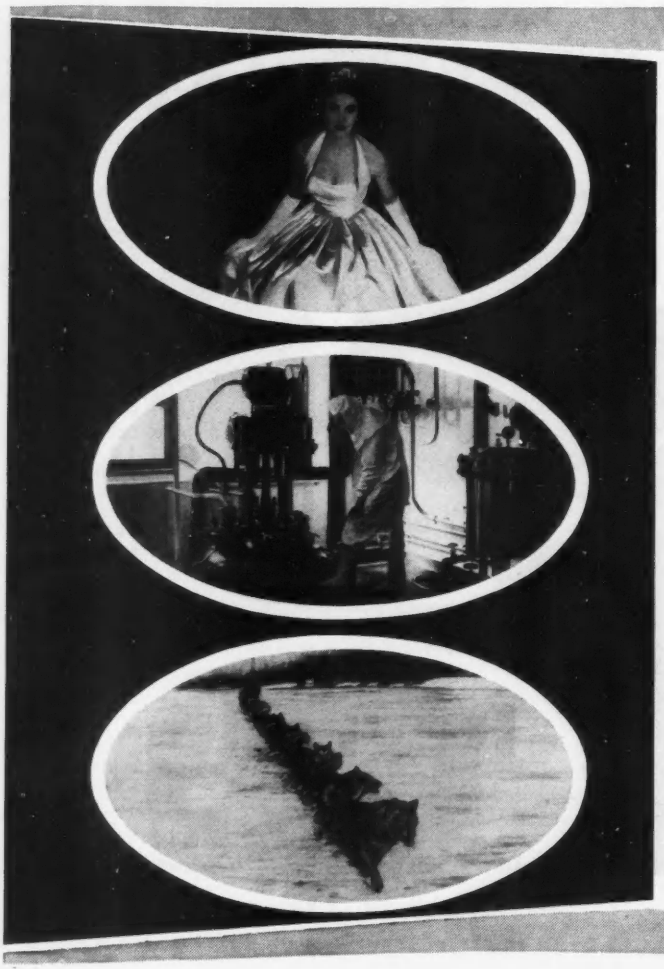

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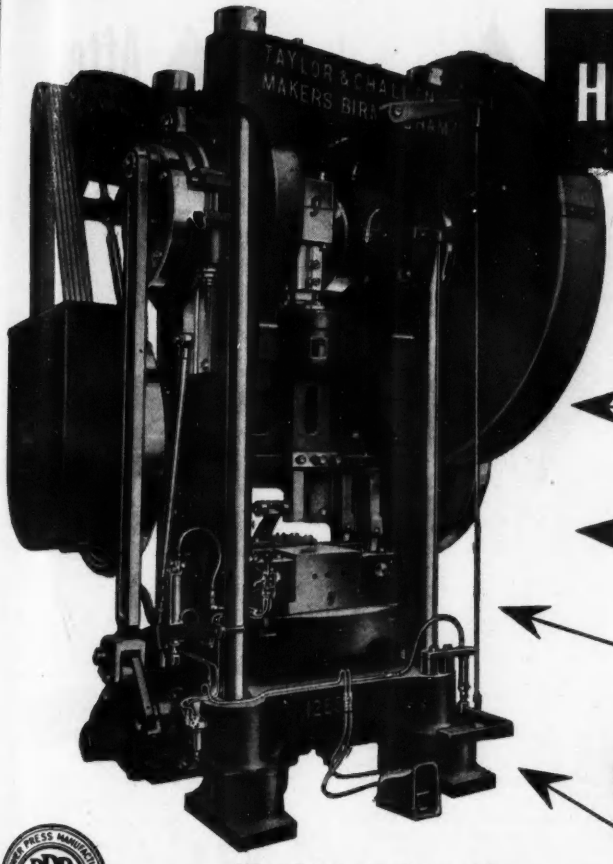

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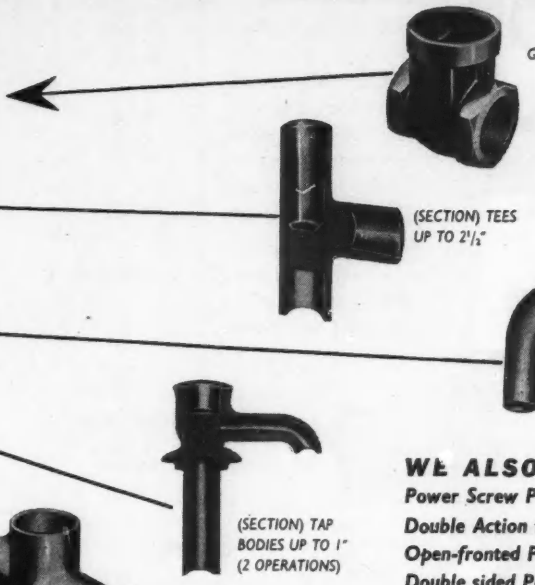

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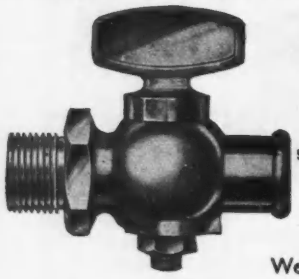

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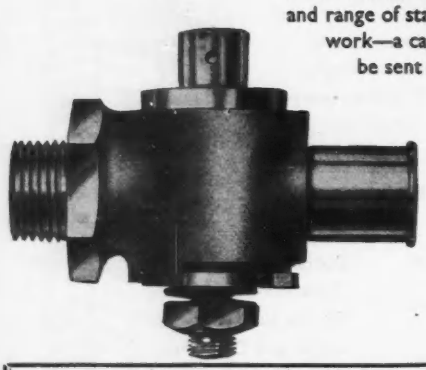

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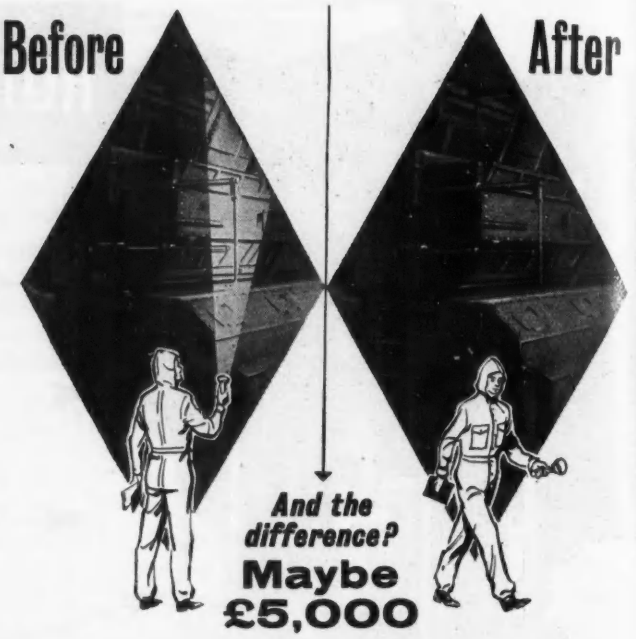

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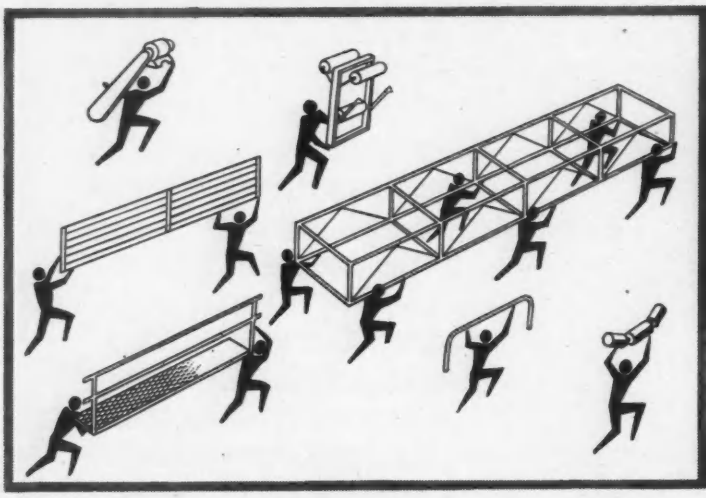

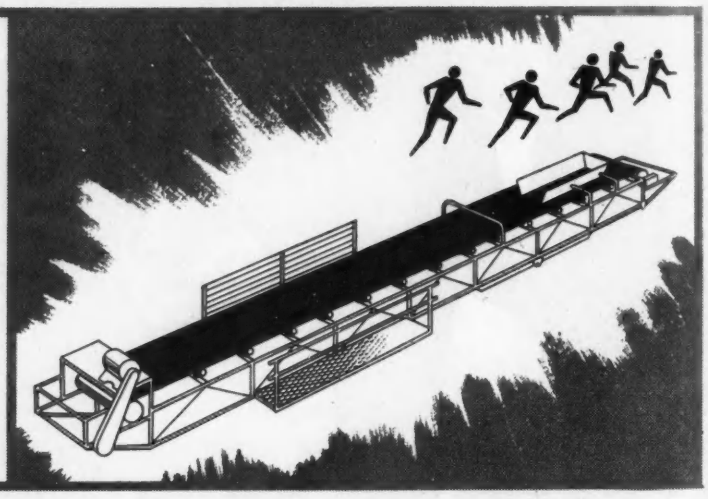

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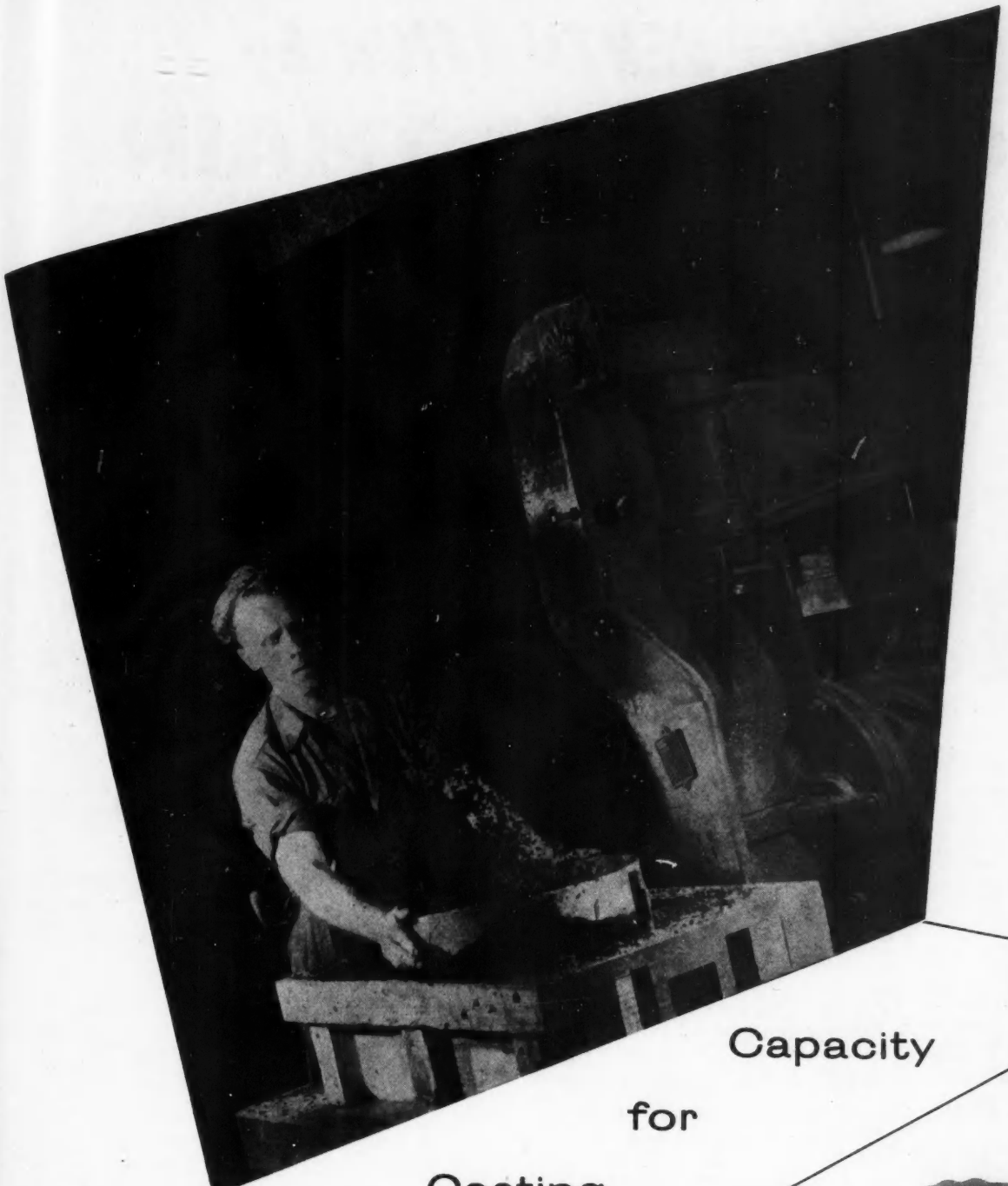

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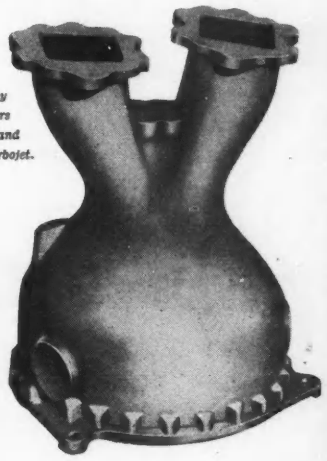

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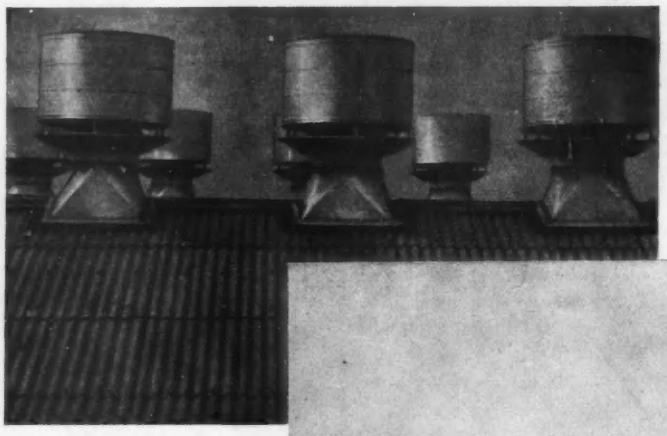

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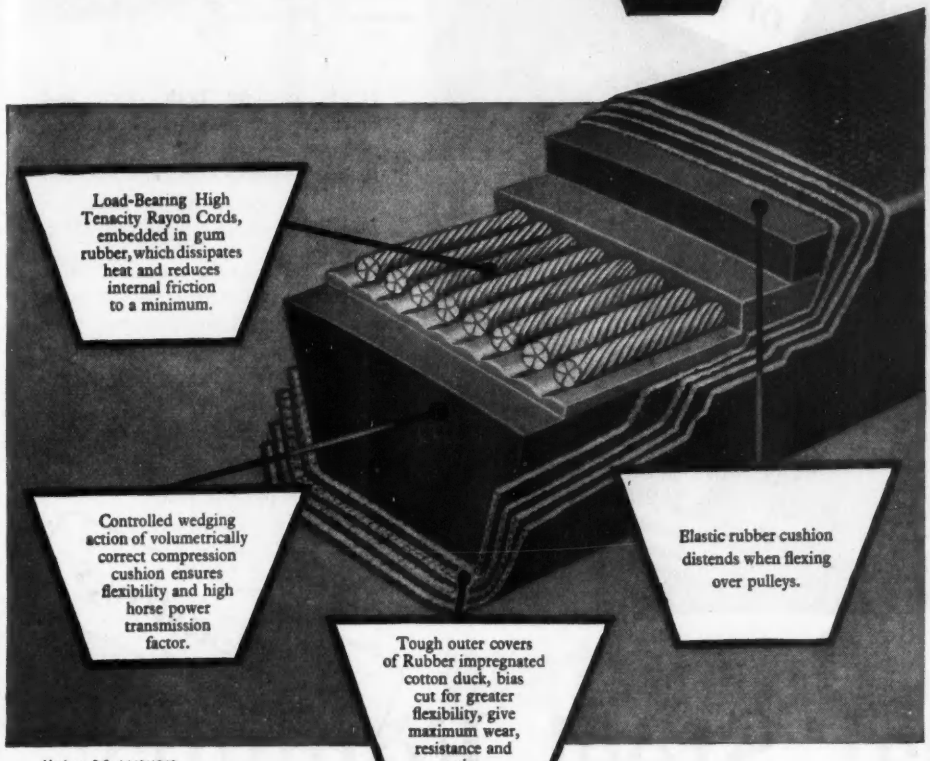
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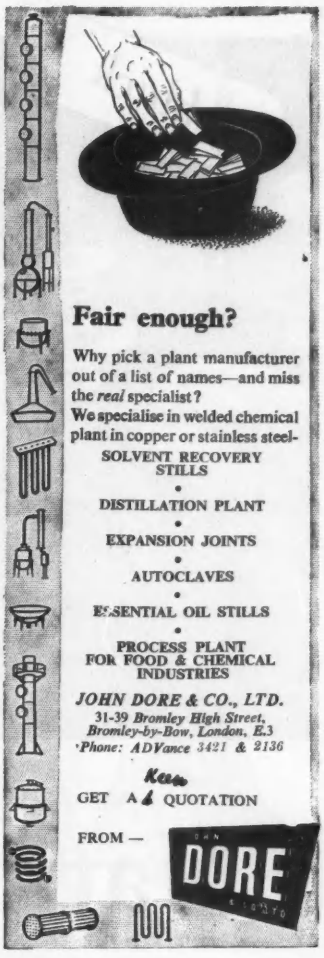

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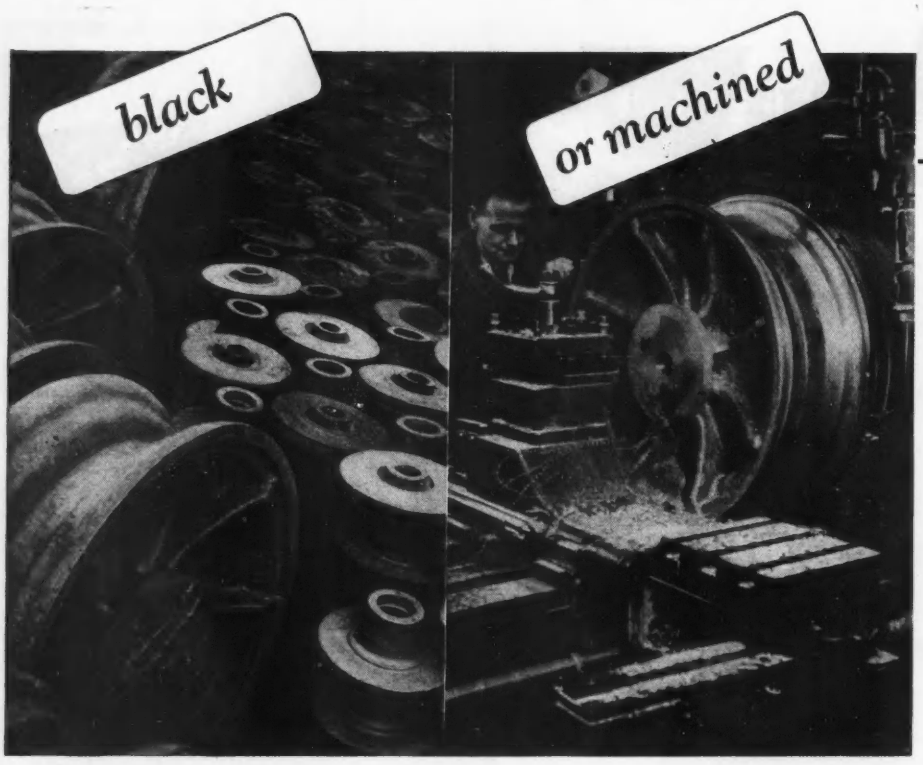

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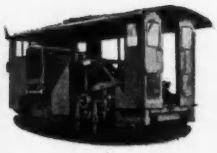

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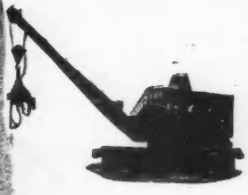

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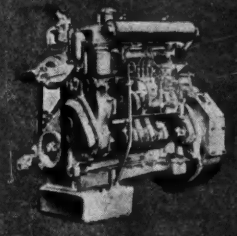

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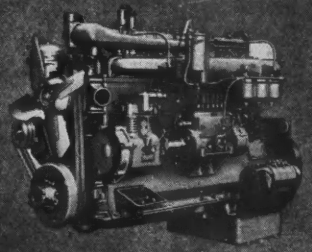

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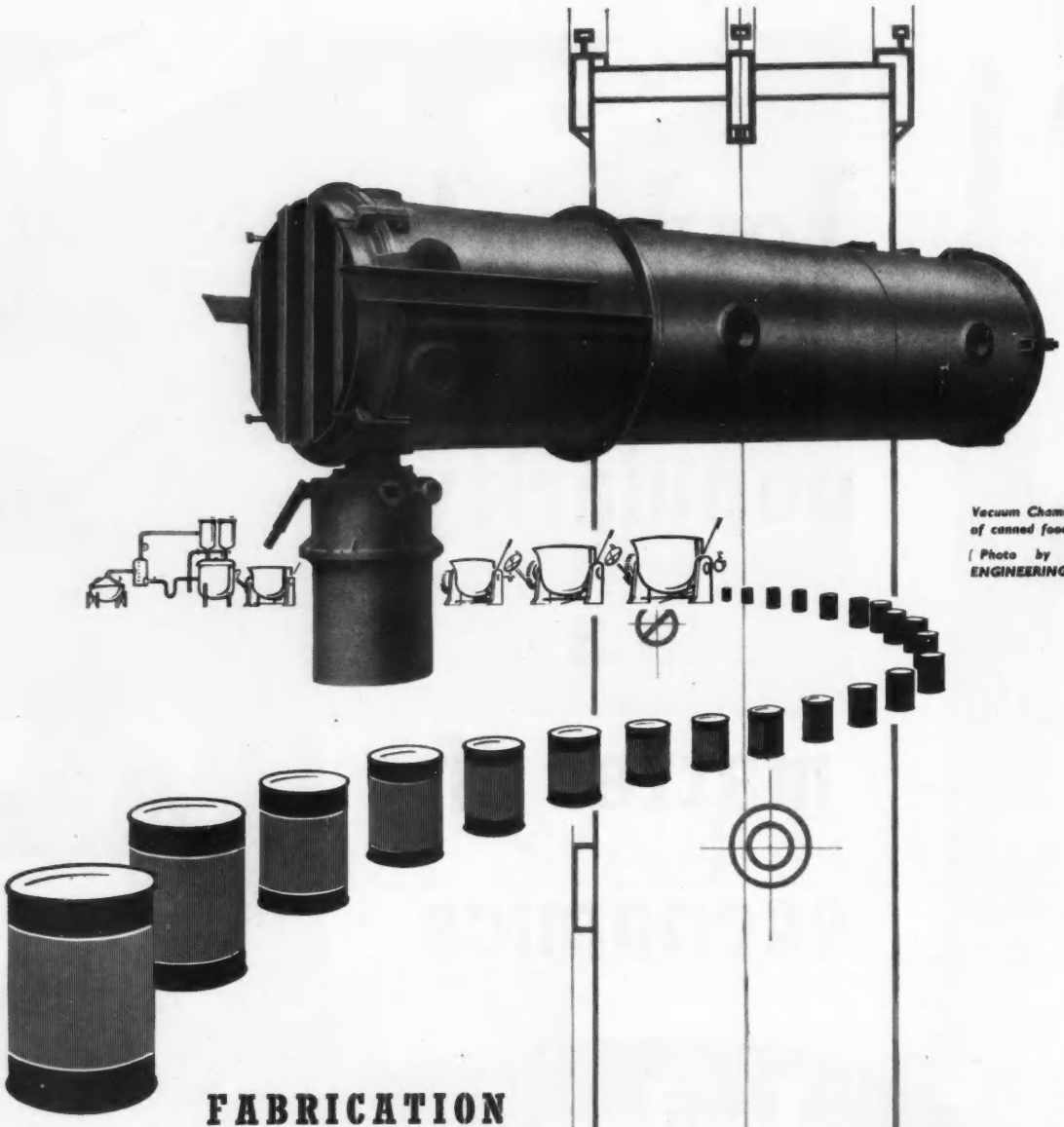

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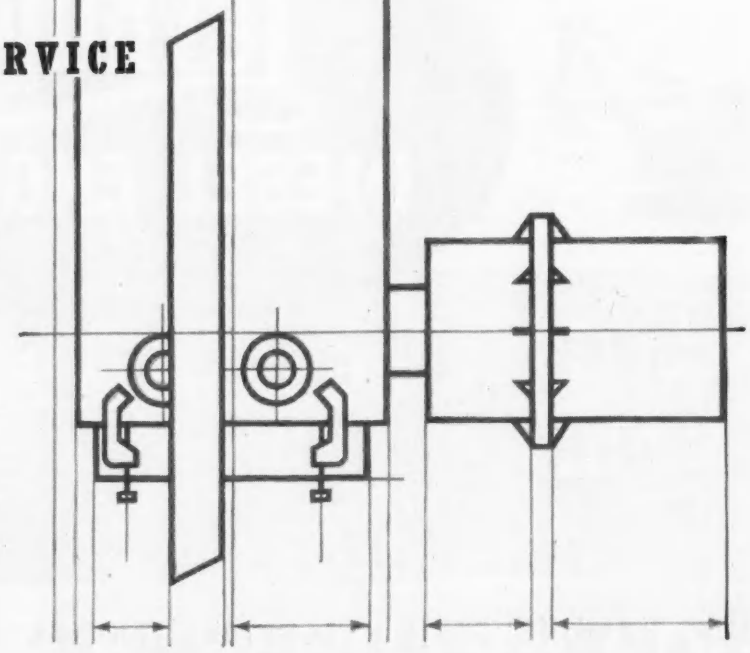

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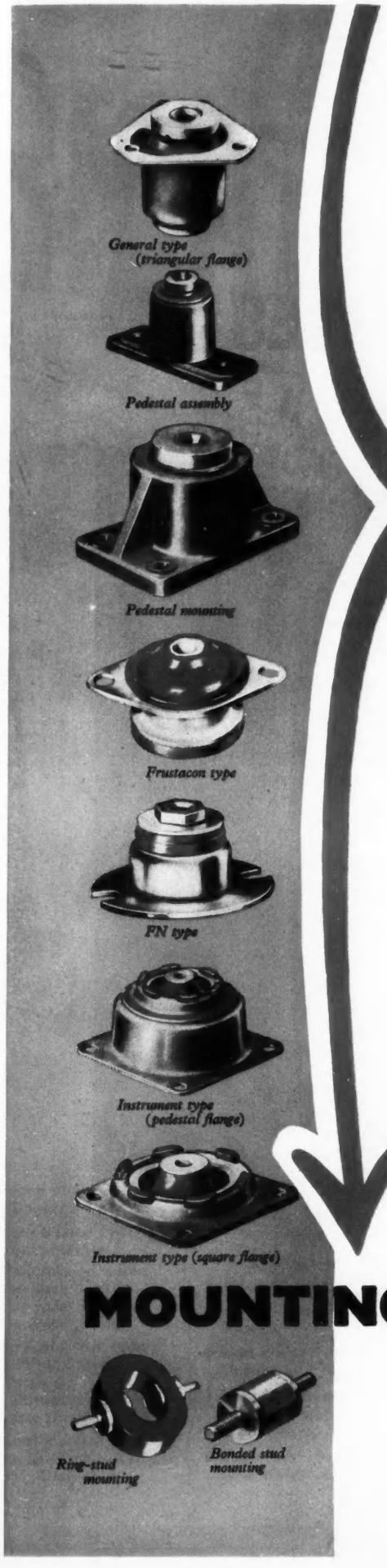

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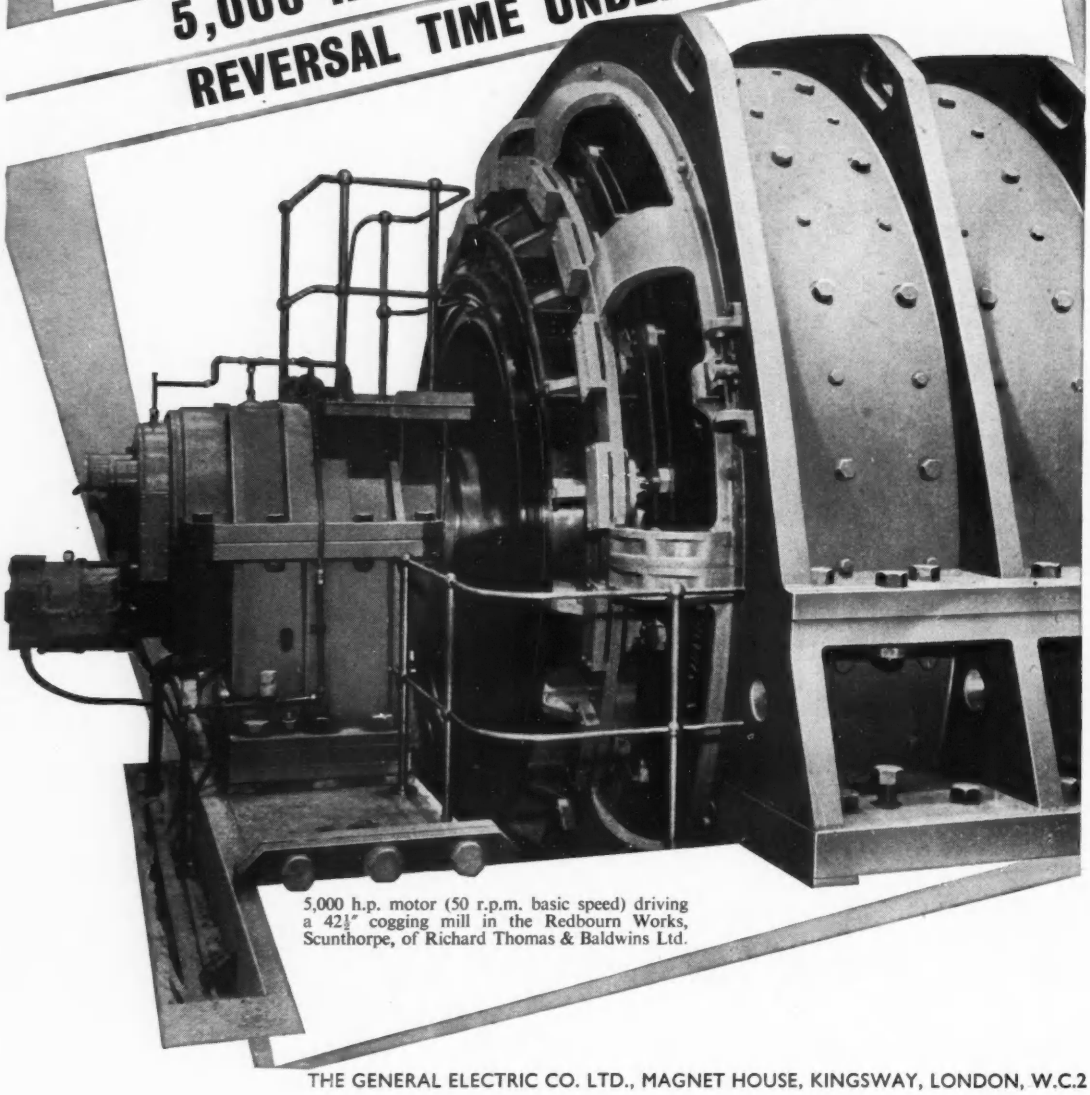

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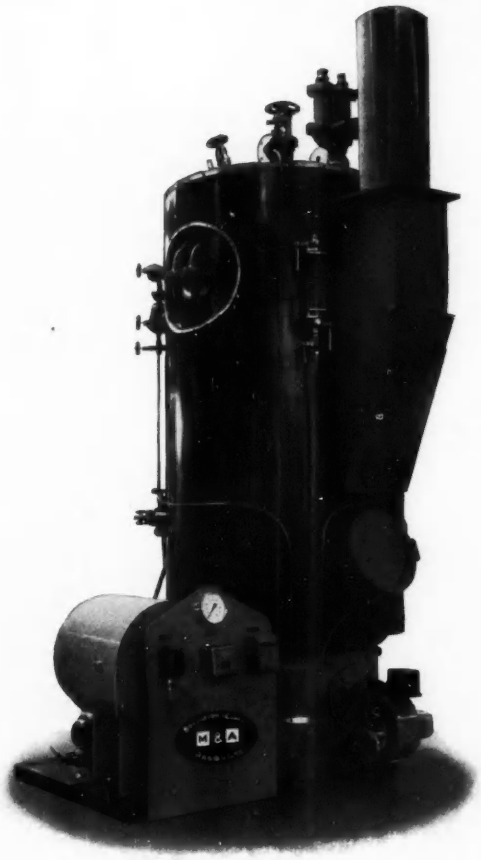

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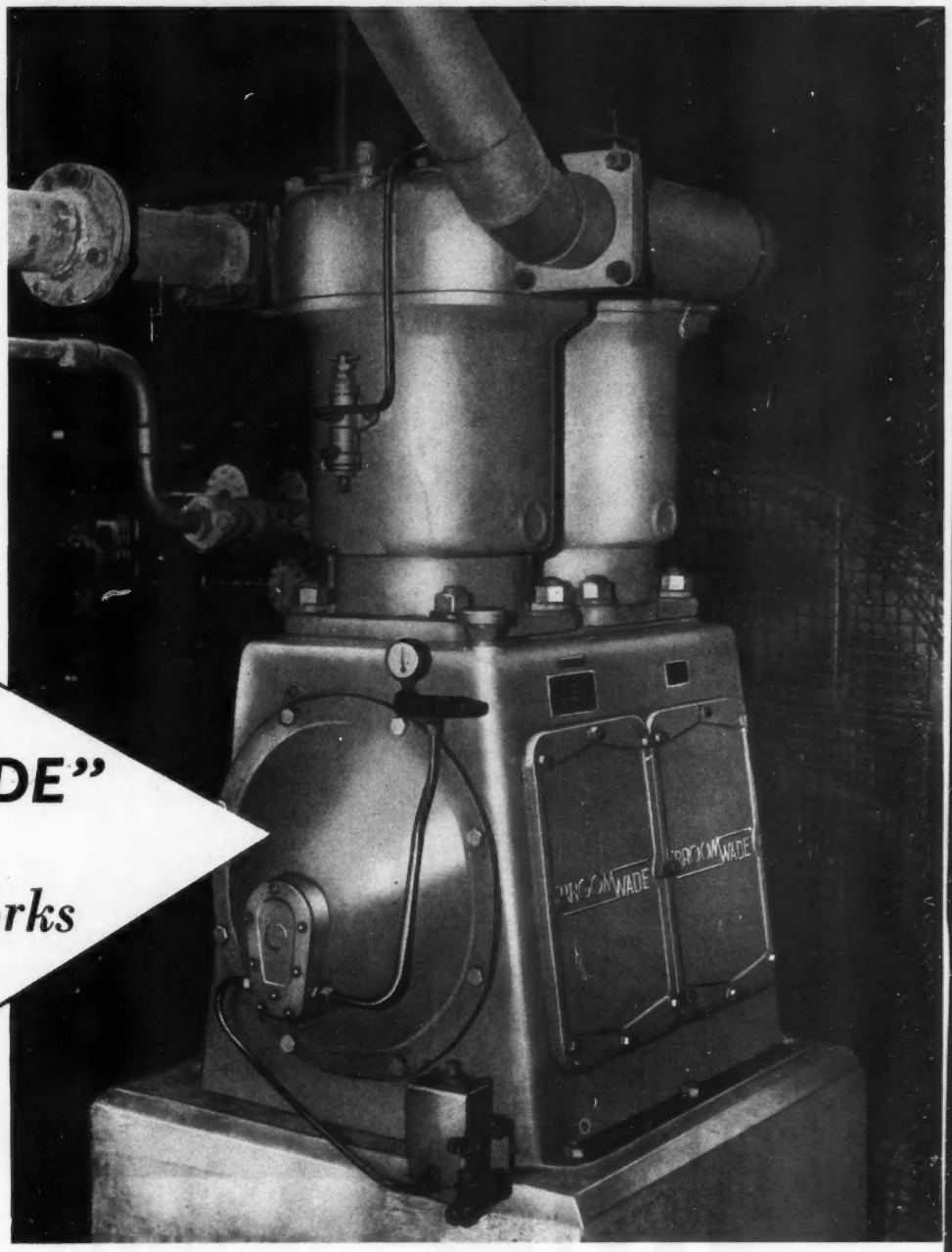

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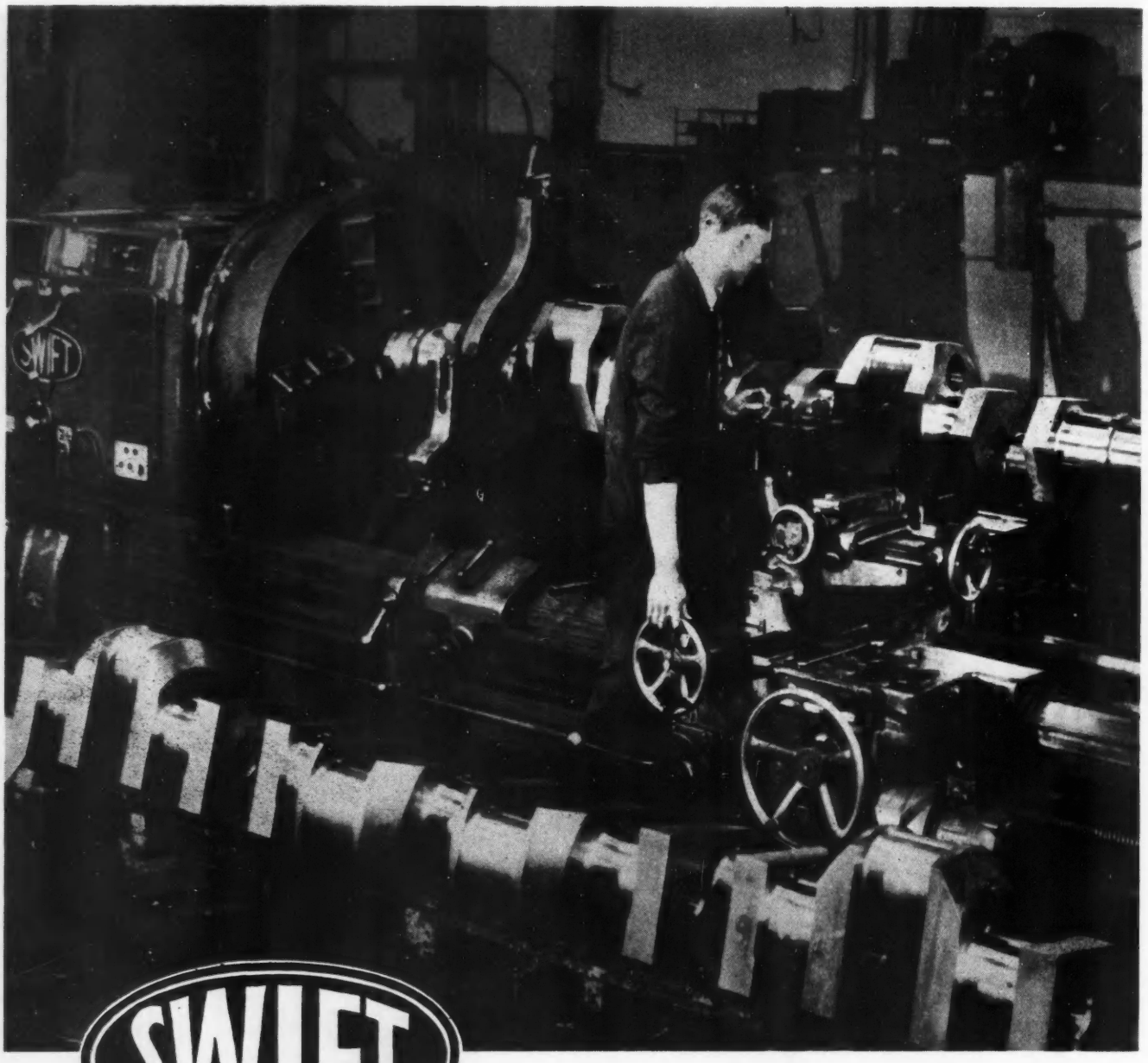

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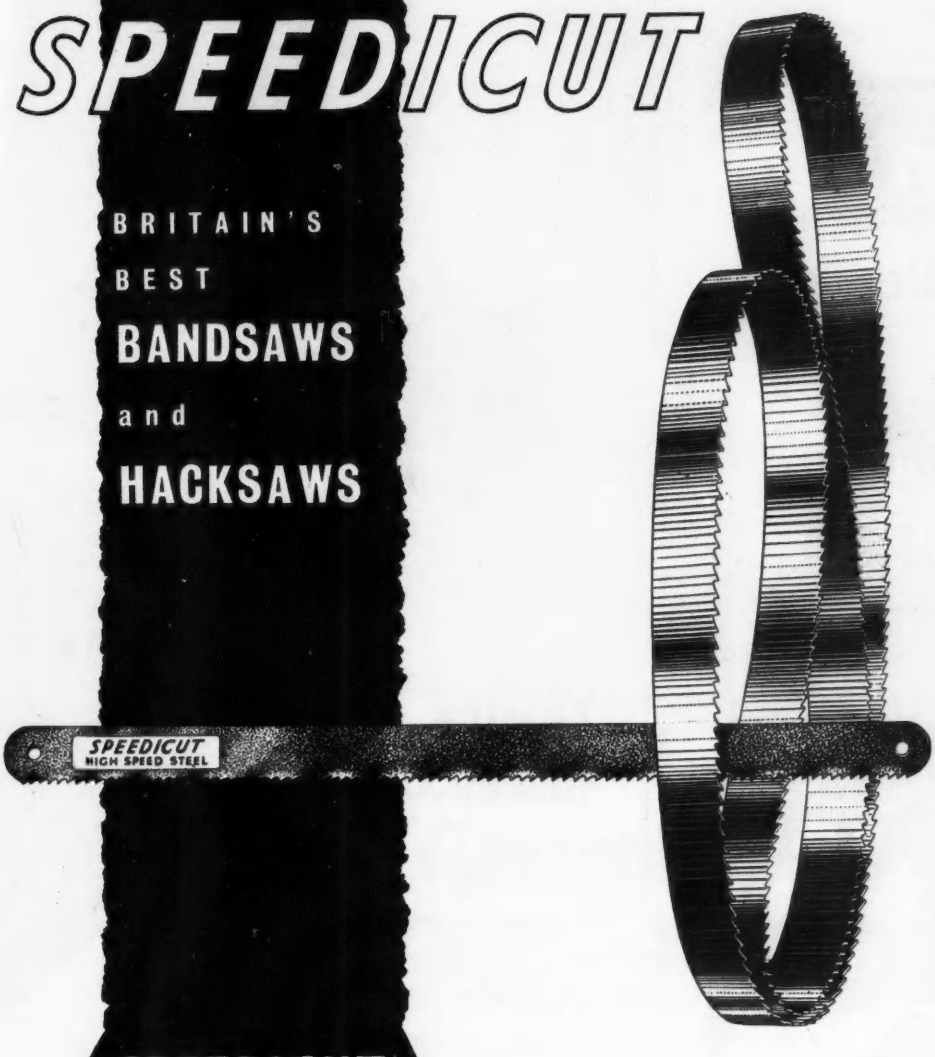

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LIGHT STEEL FABRICATIONS riveted or welded

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All enquiries promptly dealt with

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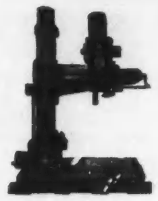
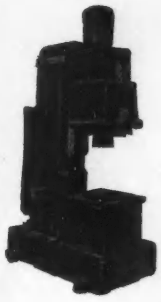

Elevating Arm Radials

Pillar Drills

Gang Drills

Honers


Automatic cycle Multis

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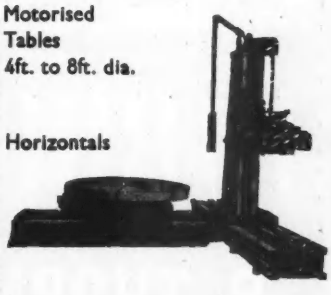
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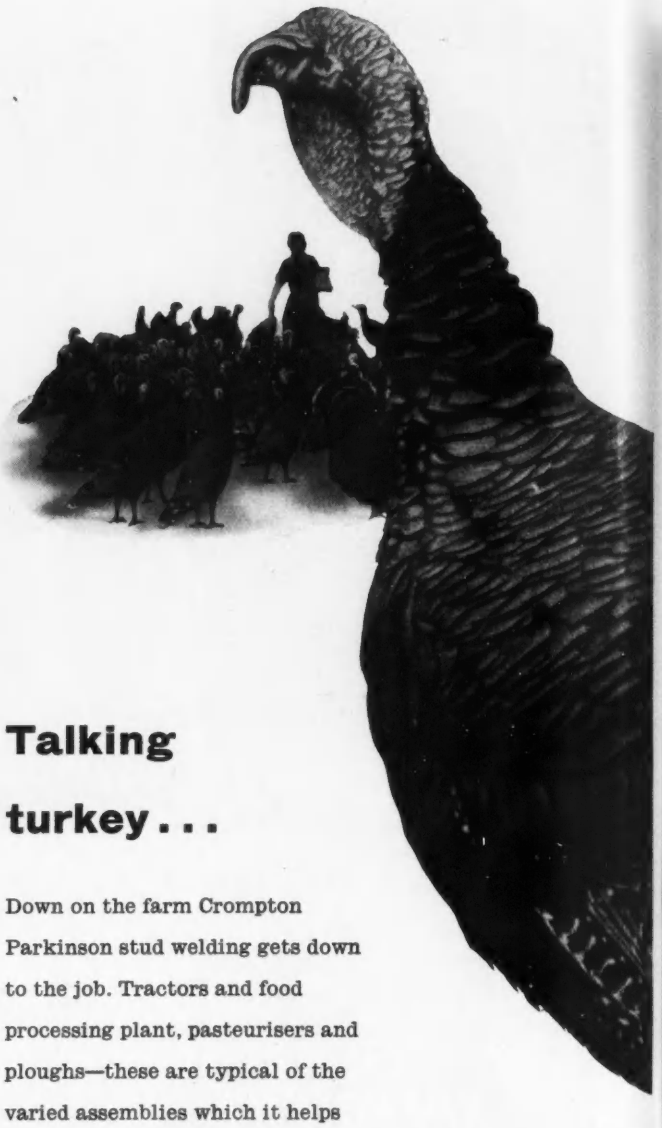
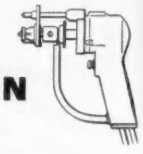


Talking turkey . . .

Down on the farm Crompton Parkinson stud welding gets down to the job. Tractors and food processing plant, pasteurisers and ploughs—these are typical of the varied assemblies which it helps to make more easily, more quickly and more cheaply. The same applies to all branches of engineering. In virtually every industry that uses metal, C.P. stud welding is at work improving designs, lowering costs and giving productivity a big boost. Care to talk turkey along these lines? We'll be glad to come along with explanation or demonstration—or both!

STUD WELDING STEPS UP PRODUCTION



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THE STUD WELDING ORGANISATION

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Joseph Booth & Bros.,
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TELEGRAMS: KELVIN, SOWEST, LONDON
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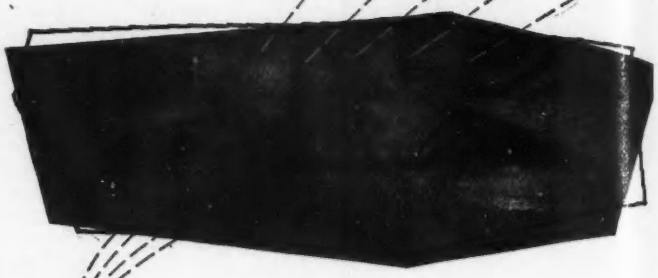
What you can't see . . .



can hurt you

Although invisible, ultra-violet and infra-red rays are definitely dangerous to welders' eyes. Continuous exposure to these rays will almost certainly result in serious eye trouble if completely adequate protection is not provided. The truly sensible way to avoid this hazard is to specify protective glass that conforms to **BS 679**. In other words, to use **Protex or Protal** . . . Chance glasses which have passed the British Standards Test.

For complete information, write for our detailed folder F.G.2

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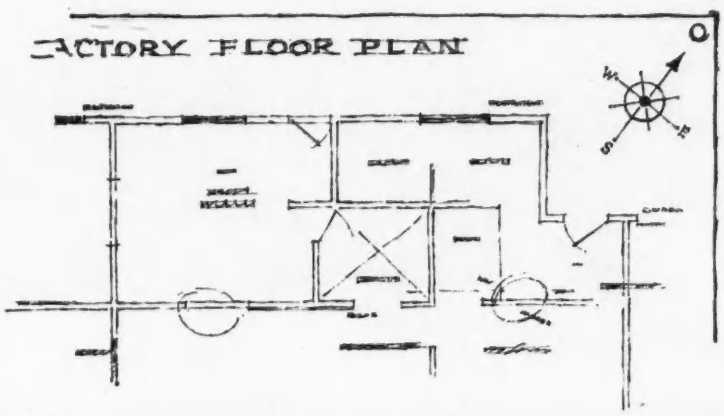

I'm a spaceman myself!

but don't get me wrong. I won't be on the first moon rocket. I'm putting my factory space which cost good money to its proper use. In other words, I'm using it to house machinery and not throwing it away on big space-wasting drives. If you think three-dimensionally, like me, you'll use chain drives, and get another machine or two on that floor.

Photograph by kind permission of Rose, Downs & Thompson Ltd., Hull.

This oil expellor installation for the treatment of oil bearing seeds and nuts is equipped with Renold Stock Chain Drives.

RENOLD chain drives conquer space problems in almost all applications

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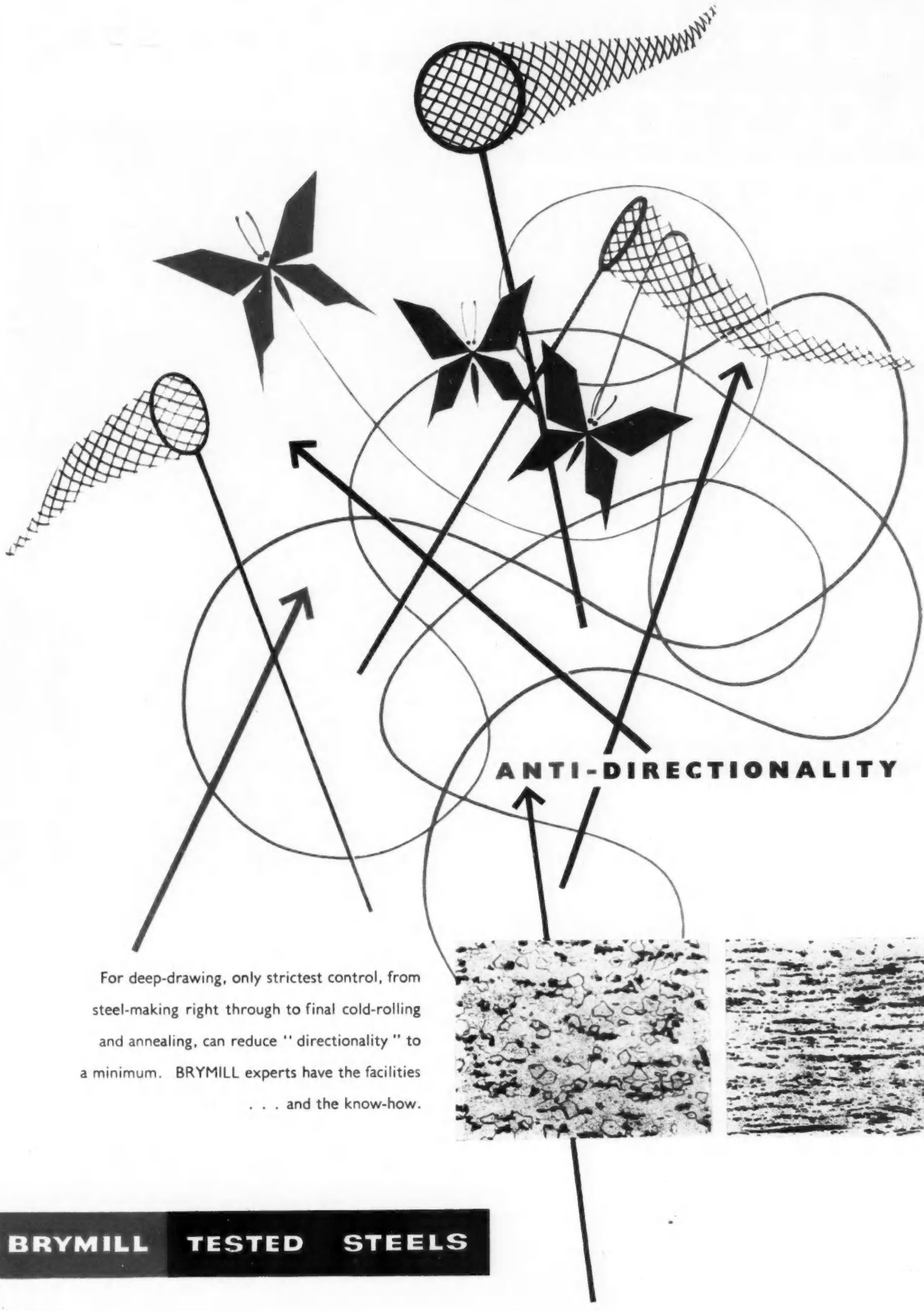

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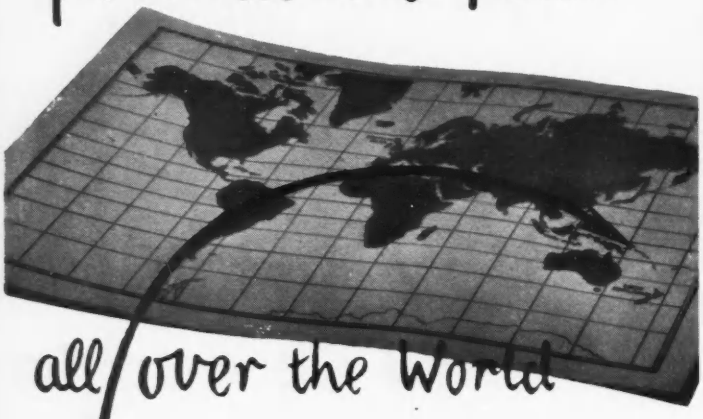
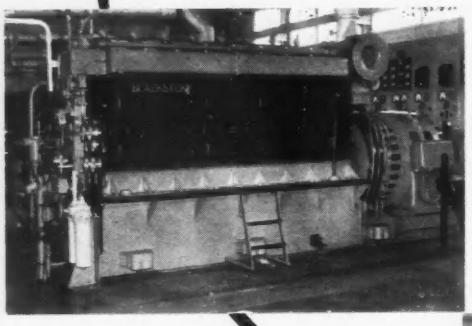


all over the World



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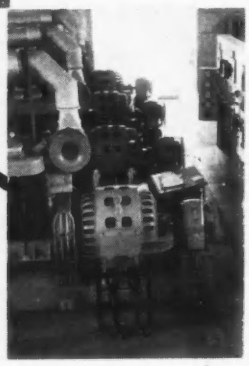

Photos by courtesy of the Commisioners of Australia Dept. of Works & Housing.

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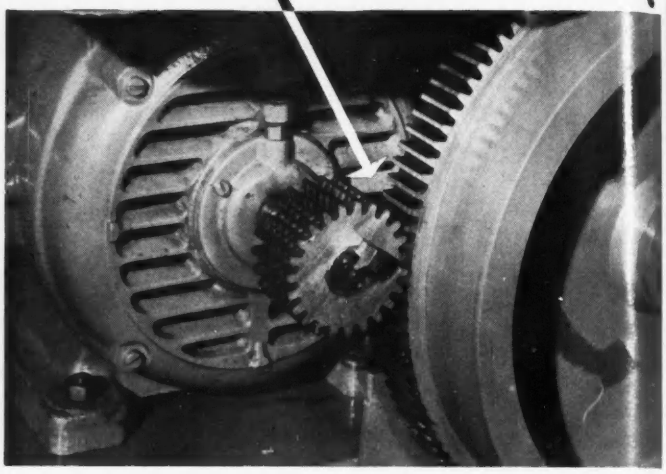

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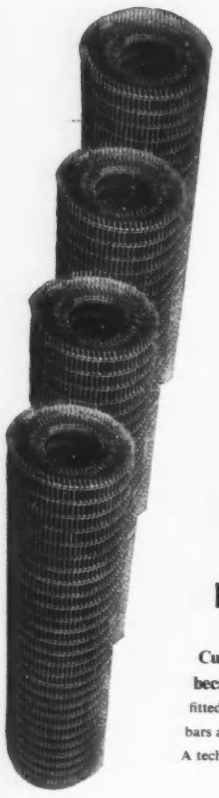

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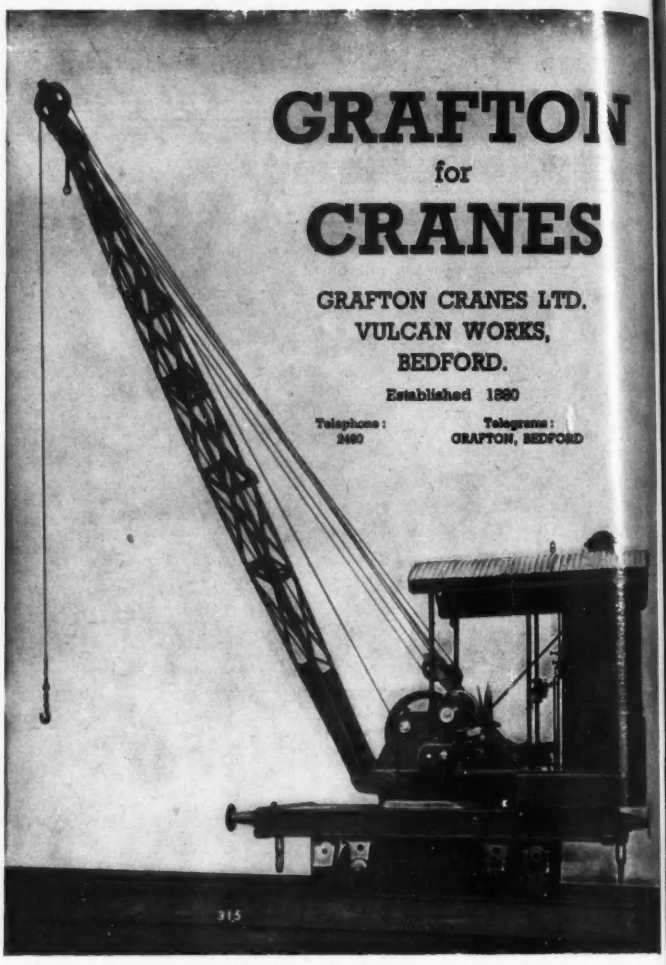

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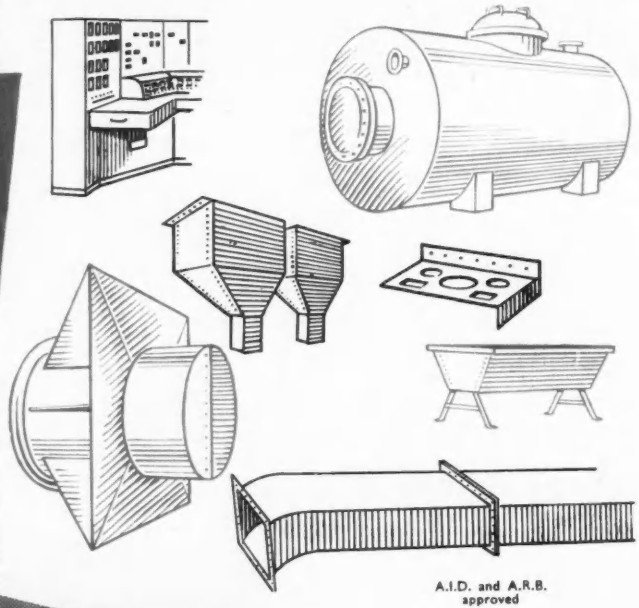

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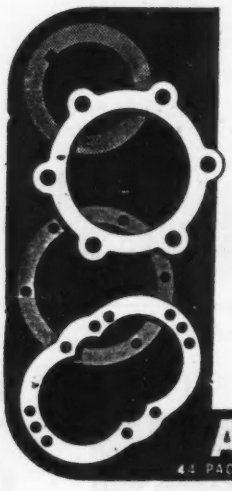

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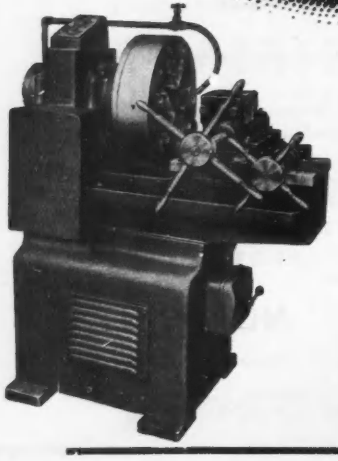

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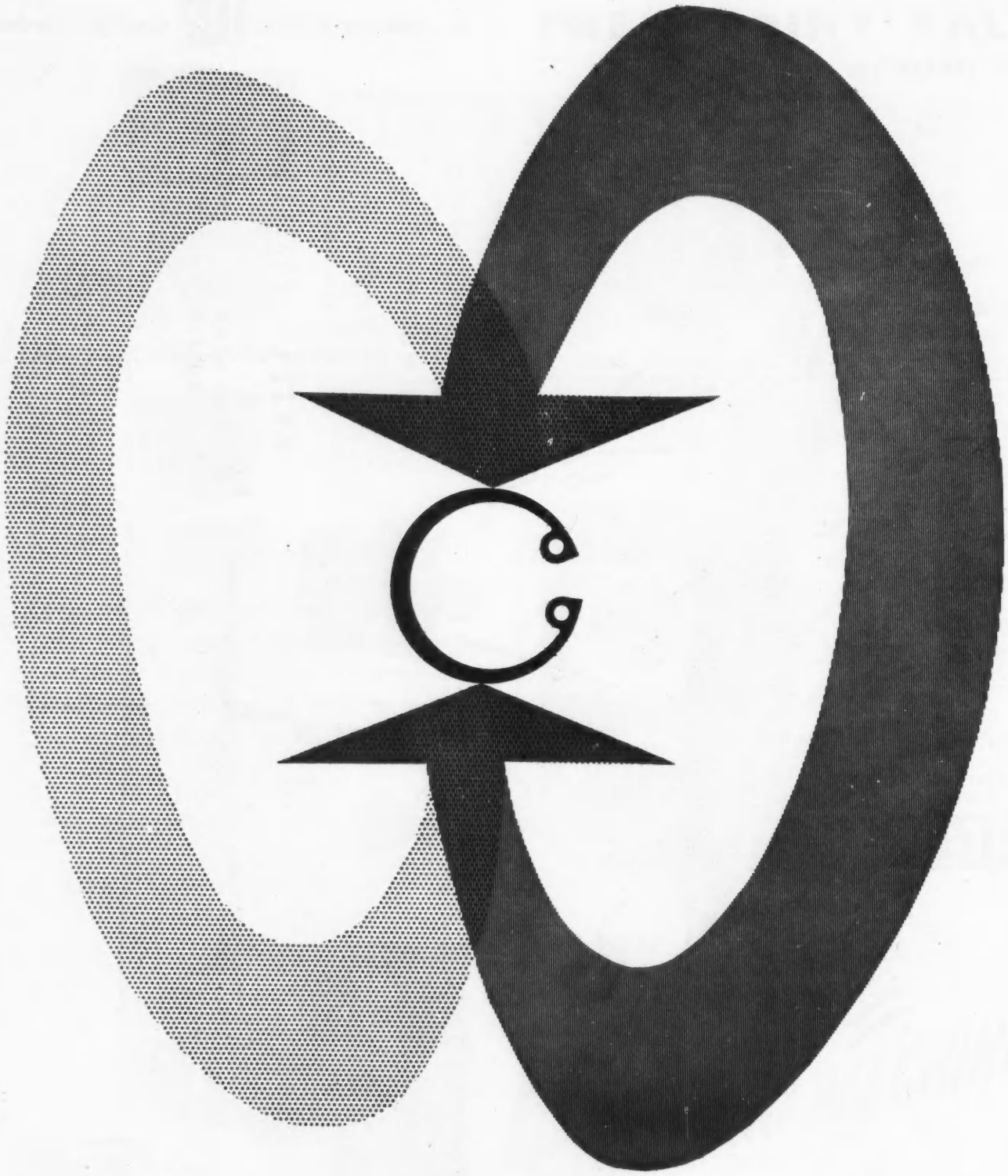

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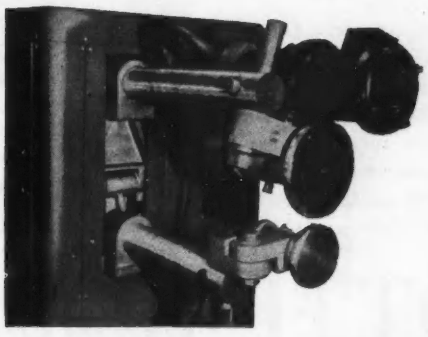

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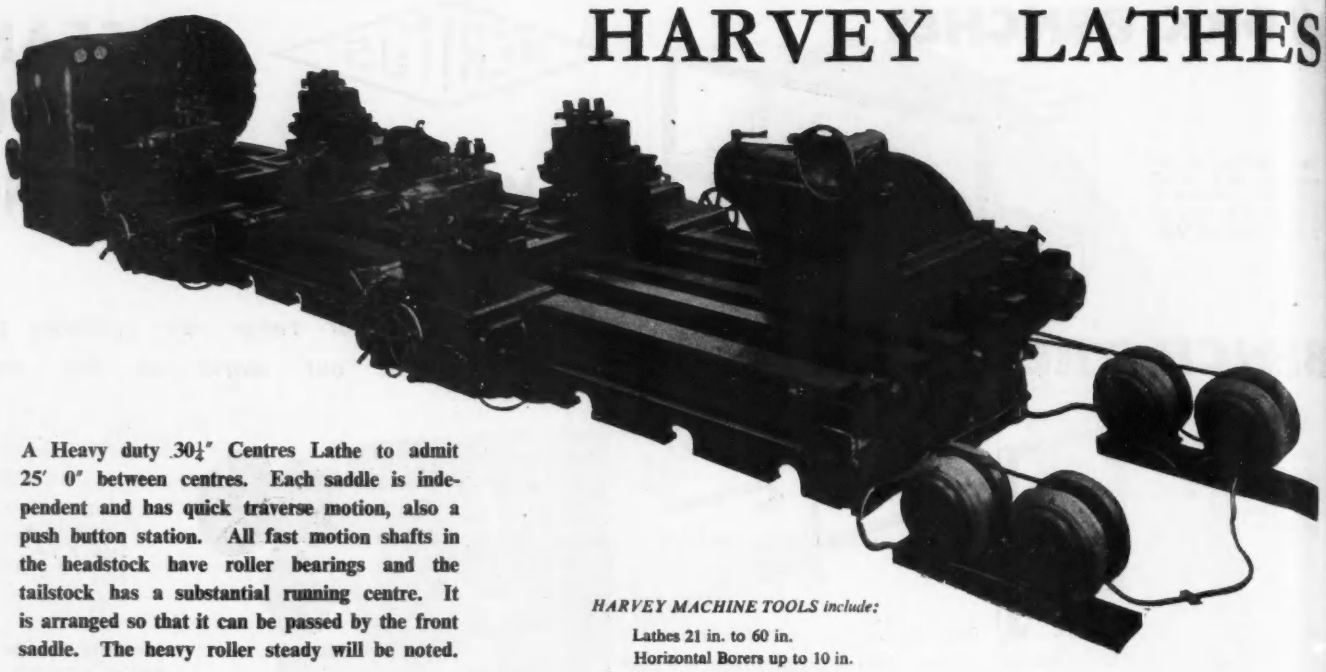
HARVEY LATHES



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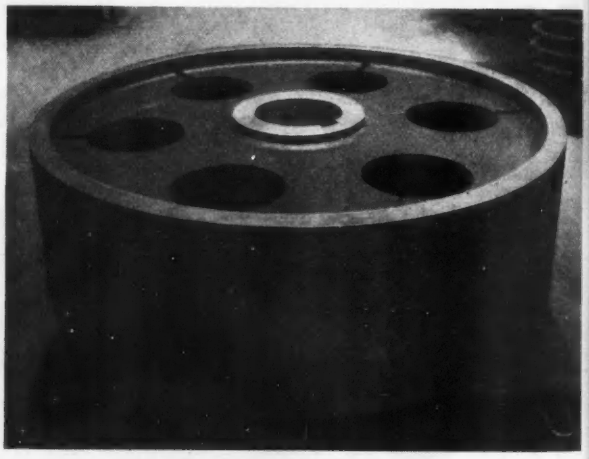
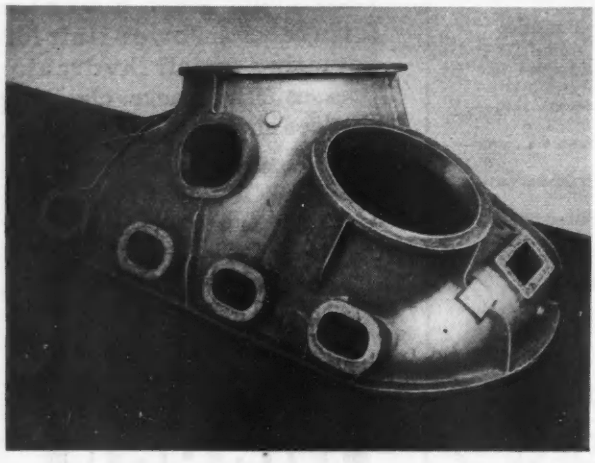


A welded gear wheel for a turbo generator set.



Casting in gunmetal of a condenser door.

Welded fabrications of all types including the welding of aluminium alloys by Argonarc process, both for Marine and Industrial applications, are carried out at our Woolston Works.

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Controlled support is always important — especially where pipes are concerned. Haphazard suspension methods are usually unsatisfactory and rarely safe. Pipe movements result in weight transfer giving rise to dangerous stresses and strains at terminal points and joints. Where pipelines are subjected to high temperatures, freedom from weight-stress is substantially minimised by installing the VOKES GENSPRING CONSTANT-SUPPORT HANGER (Top Right). Scientifically designed and constructed, light and compact, they are available for loads of up to 30,000 lbs. over a range of movement up to 12", giving complete control.

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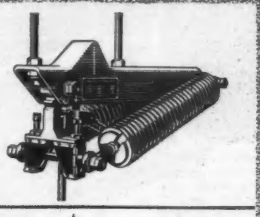

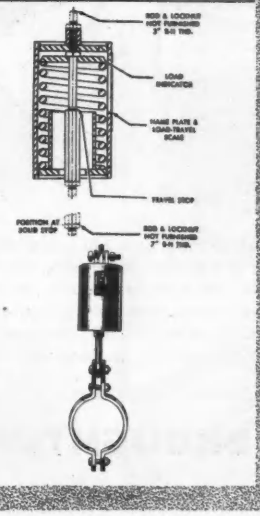

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SUSPENSION SYSTEMS

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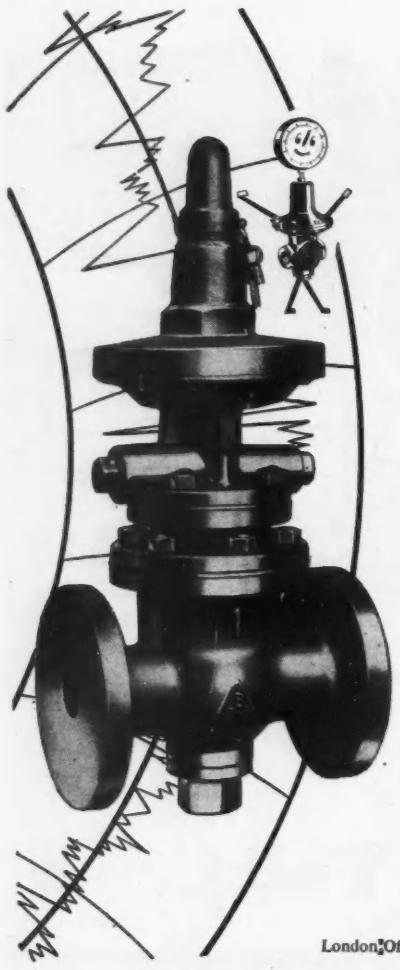

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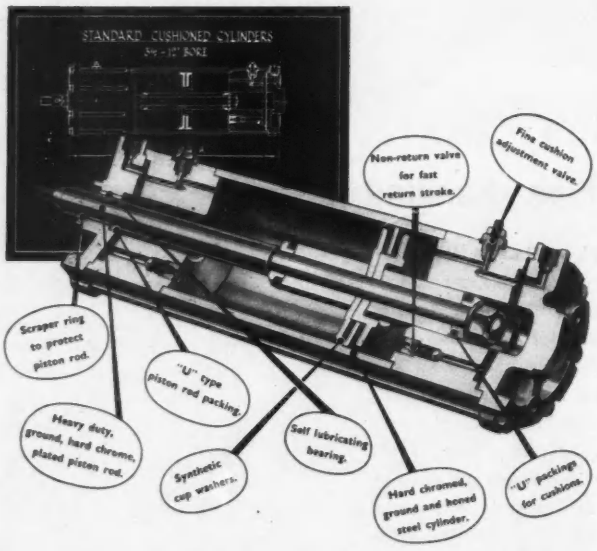
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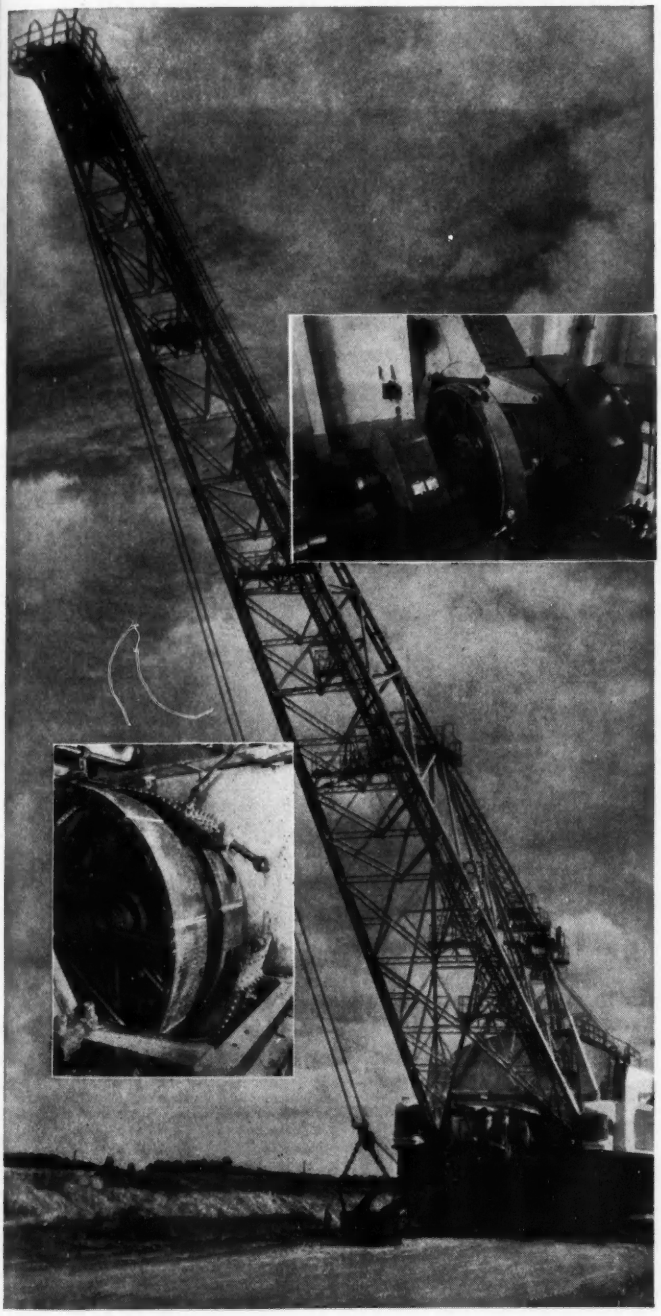

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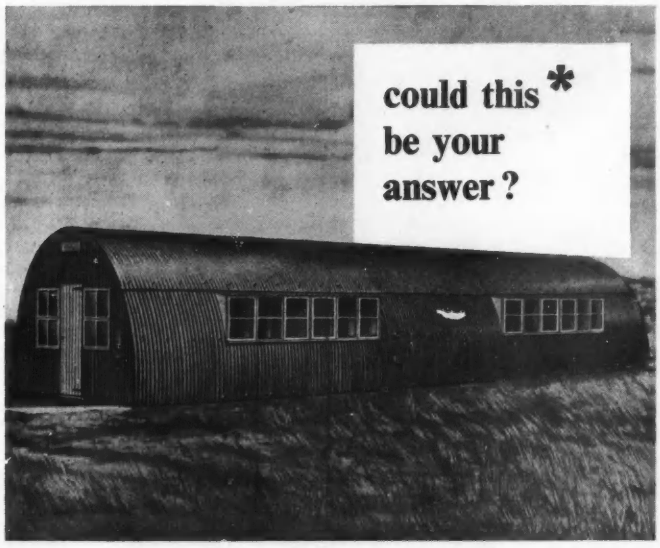

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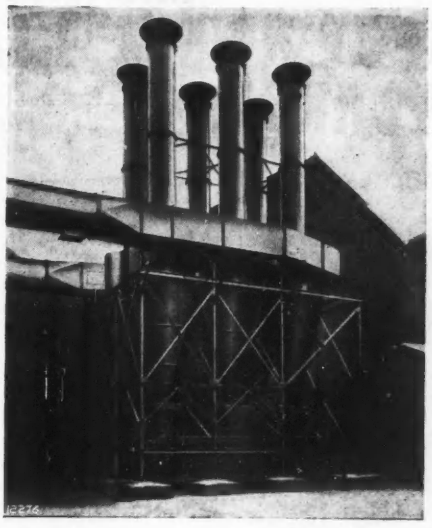

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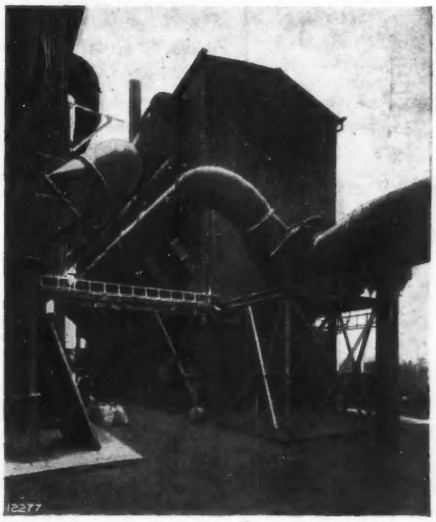

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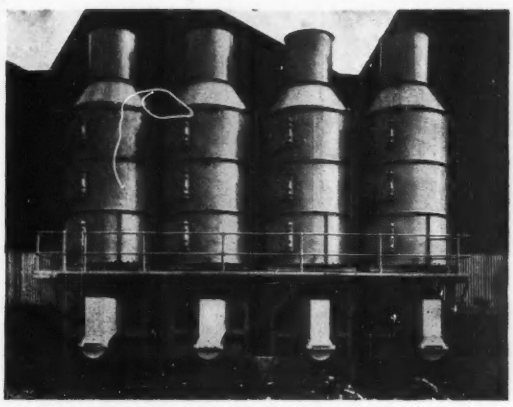

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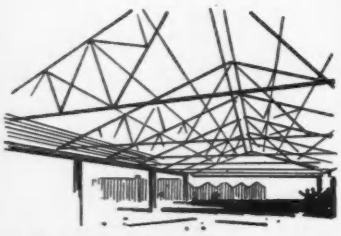

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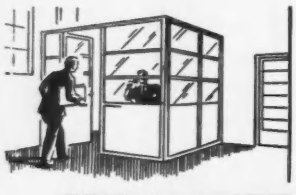

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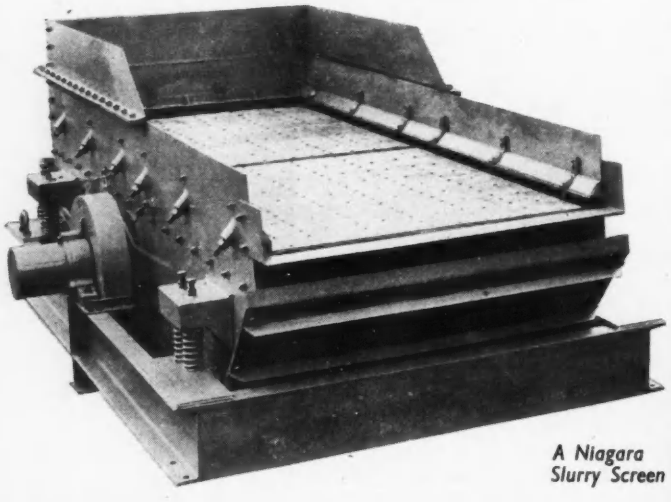

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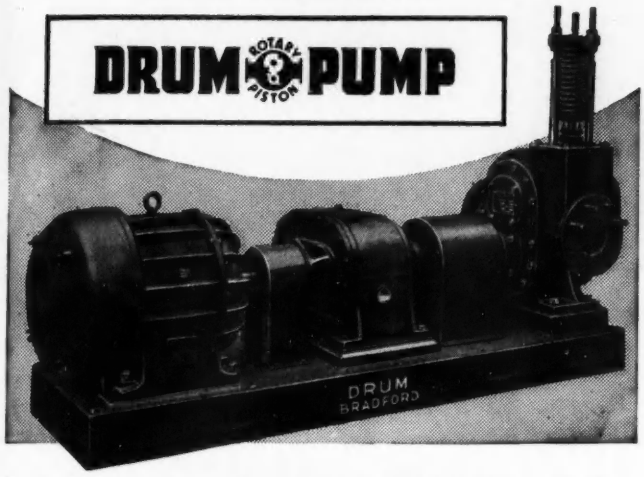

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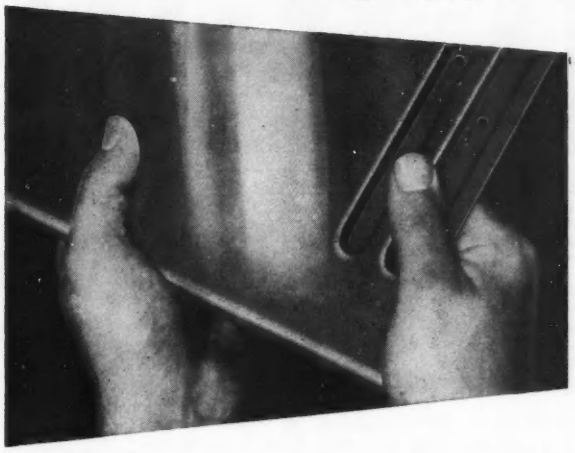

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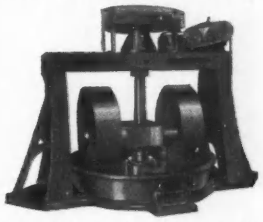

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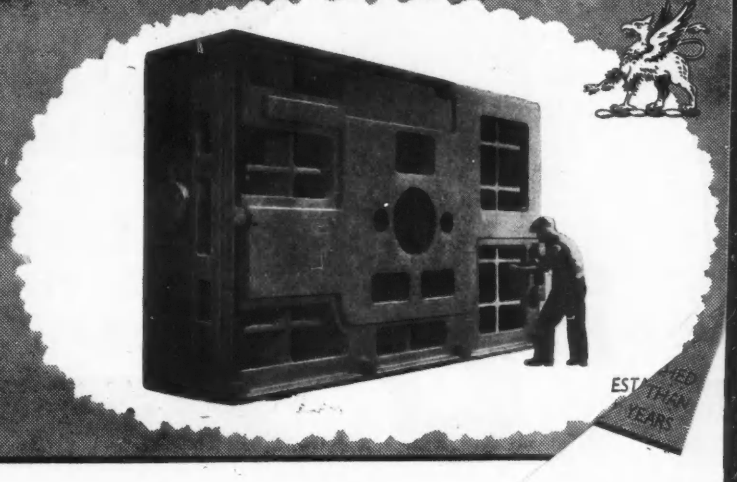
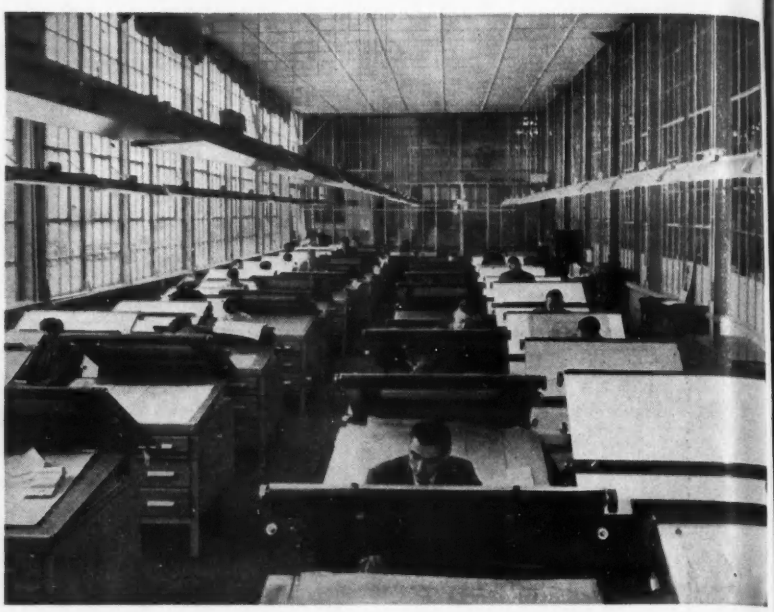


DRAWING OFFICE PROGRESS



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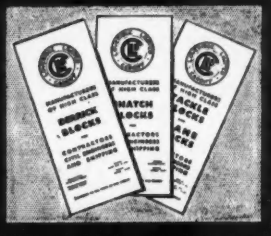

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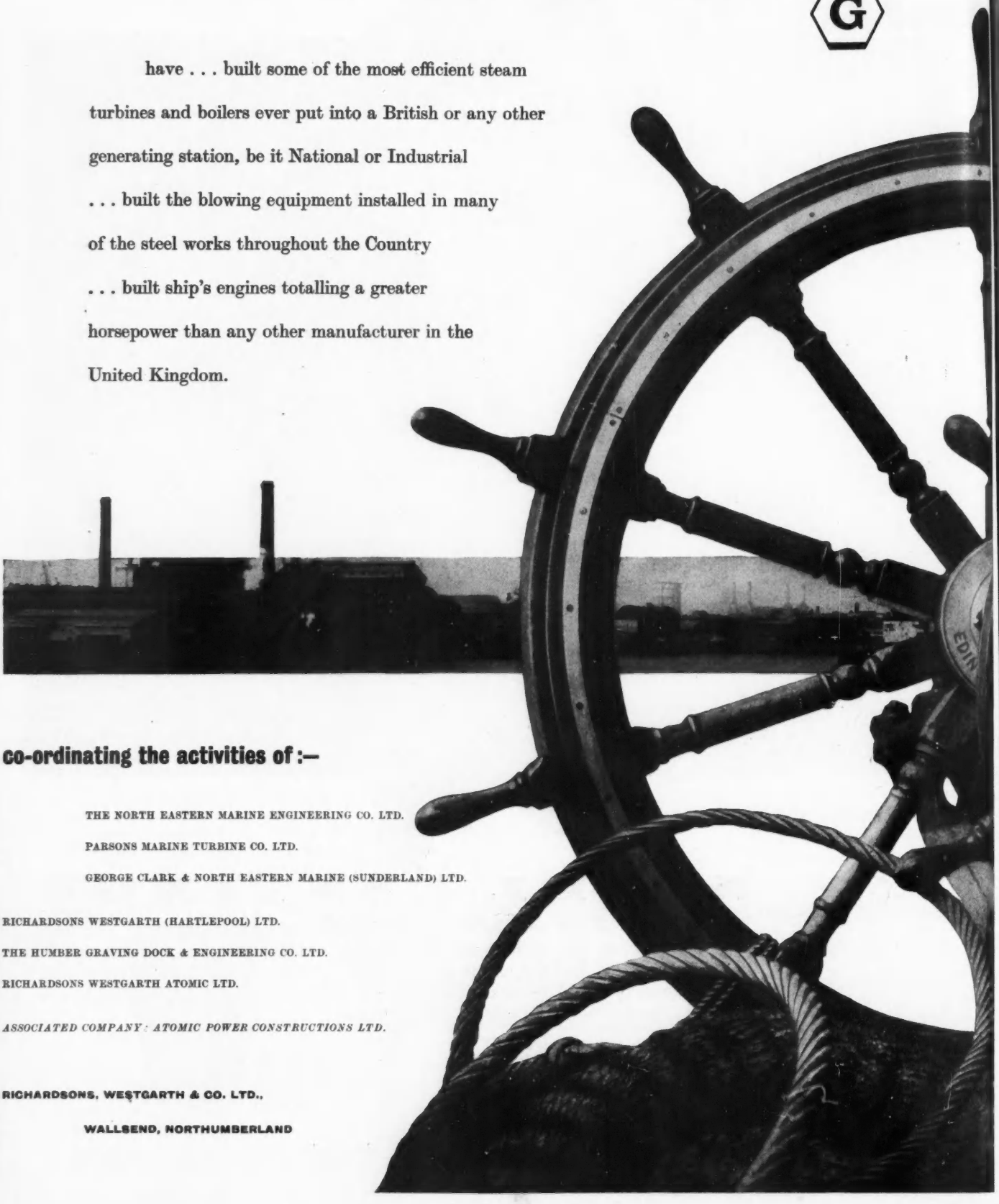

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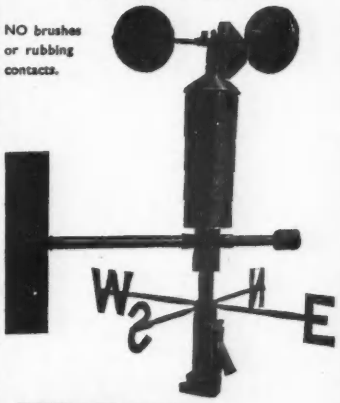

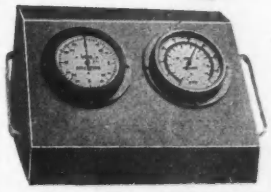

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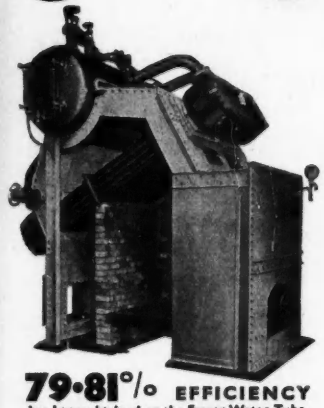

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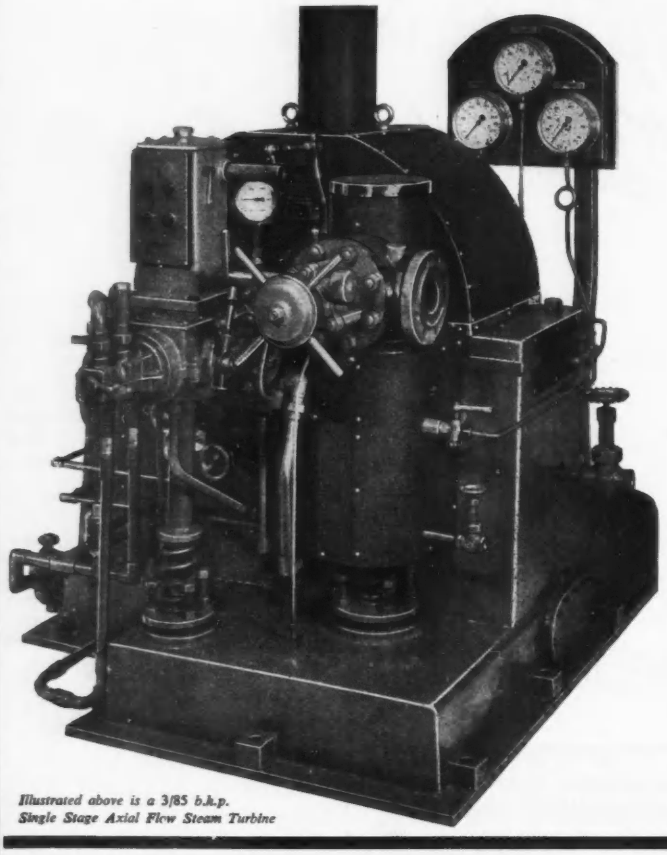

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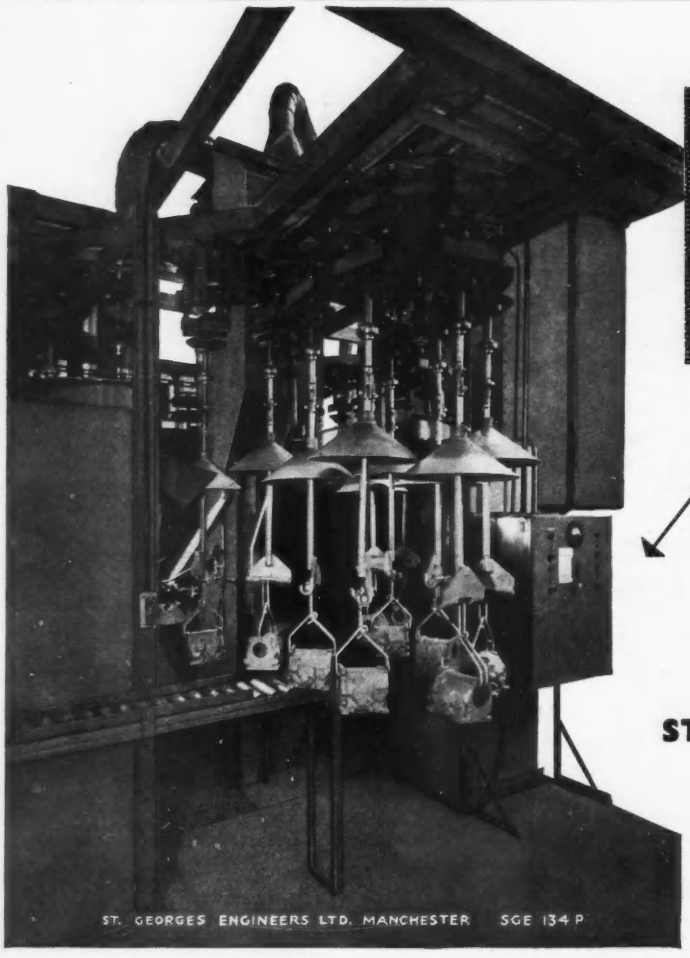

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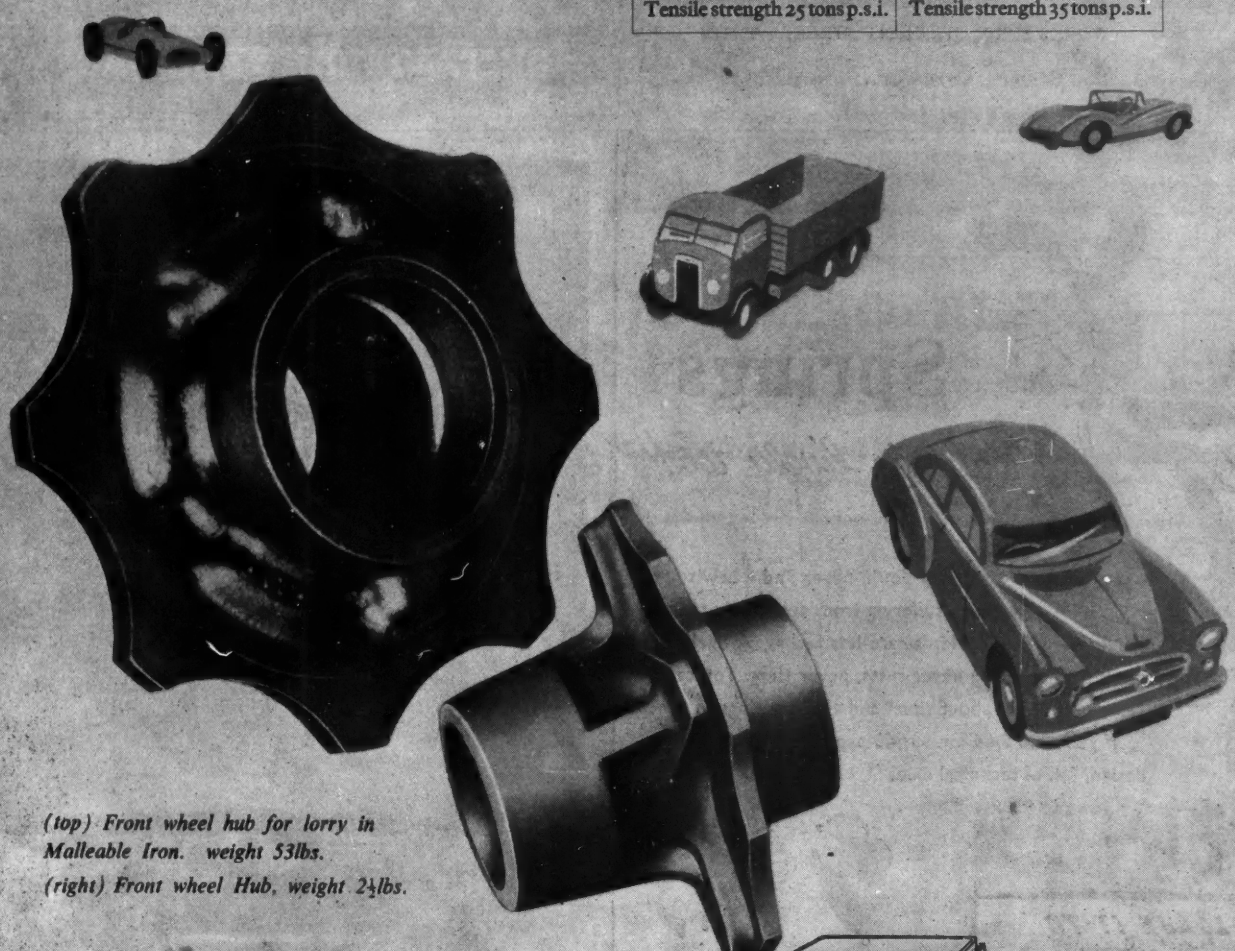

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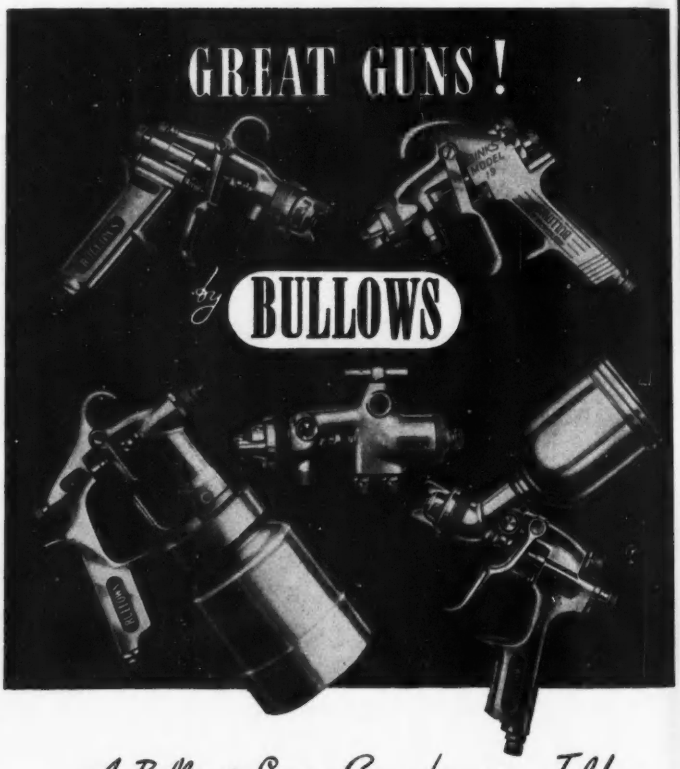

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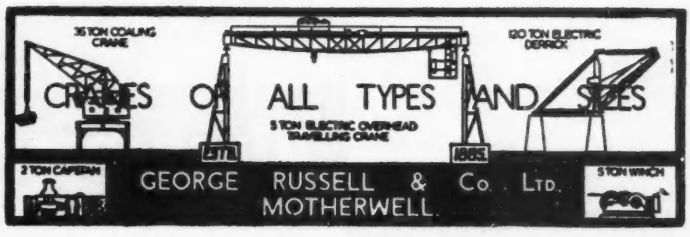
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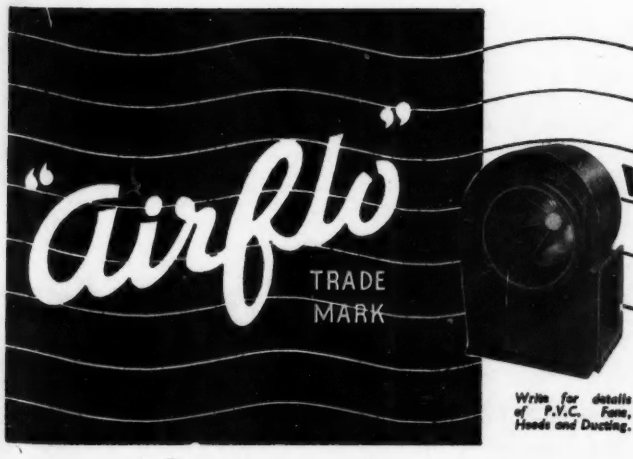

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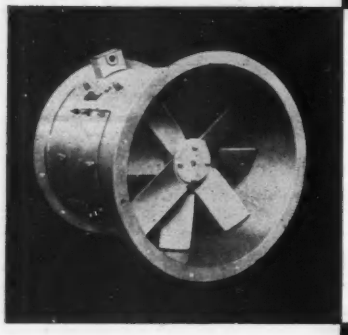

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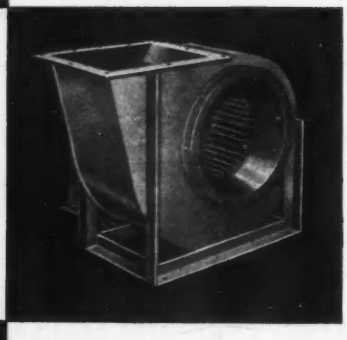

Airscrew Centrifugal Fans —Forward Curve, Paddle Blade and Backward Curve —between them cover nearly all cases where a centrifugal fan is indicated.

—*Specifications that mean what they say*

These two AIRSCREW standard Fan Ranges—Axial Flow and Centrifugal—can usually be relied upon to provide the fan you need at the time you need it. Every phase of design and manufacture is so closely controlled that we *guarantee* no AIRSCREW Fan will give less than its rated duty—though it may give more. The Airscrew Technical Service is ready and willing to assist in the selection of the correct fan whether from standard range or individually designed.

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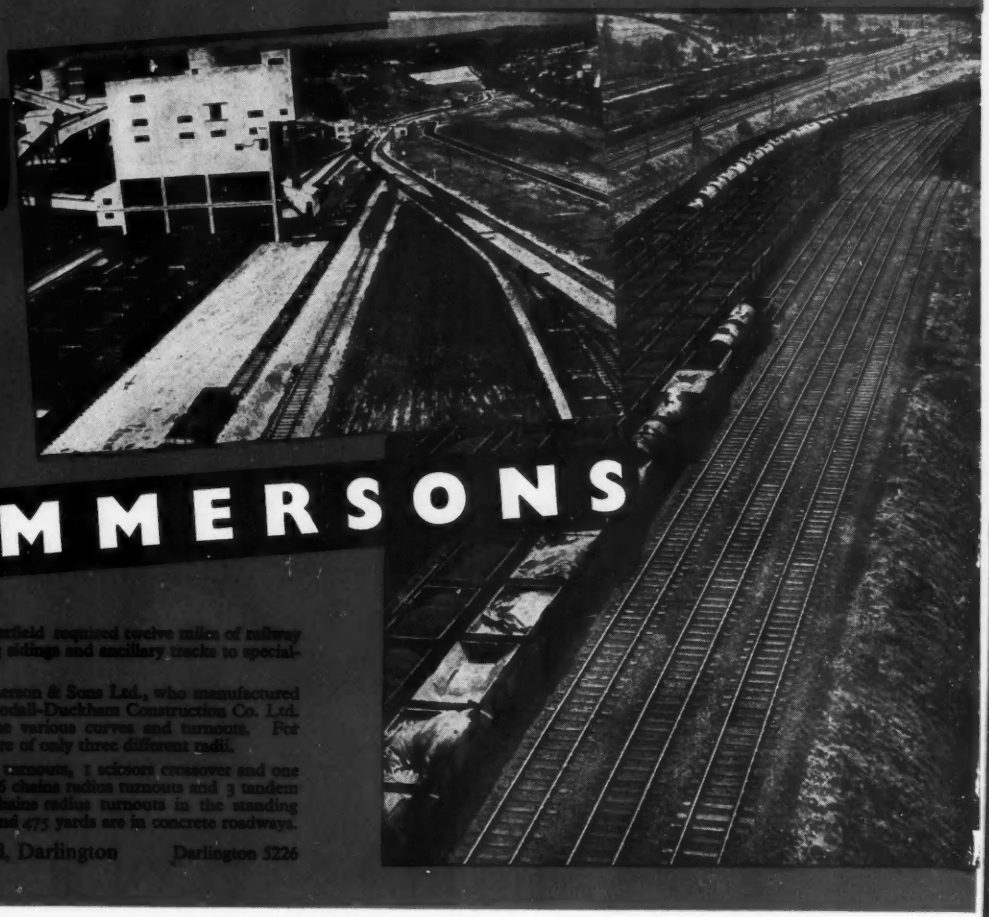
AVENUE CARBONISATION AND CHEMICAL PLANT — CHESTERFIELD

yet another big railway siding by SUMMERSONS



This important coal carbonisation project at Chesterfield required twelve miles of railway track, comprising reception, marshalling and standing sidings and ancillary tracks to specialised plans.

The complete layout was entrusted to Thos. Summerson & Sons Ltd., who manufactured and installed the track for the main contractors, Woodall-Duckham Construction Co. Ltd. The design was a triumph of standardisation of the various curves and turnouts. For example although 98 turnouts were supplied, they were of only three different radii.

The system includes twenty-five 9 chains radius turnouts, 1 scissors crossover and one tandem turnout in the reception siding; twenty-eight 6 chains radius turnouts and 3 tandem turnouts in the marshalling sidings and thirty-one 3 chains radius turnouts in the standing sidings. Of the total mileage, 3,200 yards are curved, and 475 yards are in concrete roadways.

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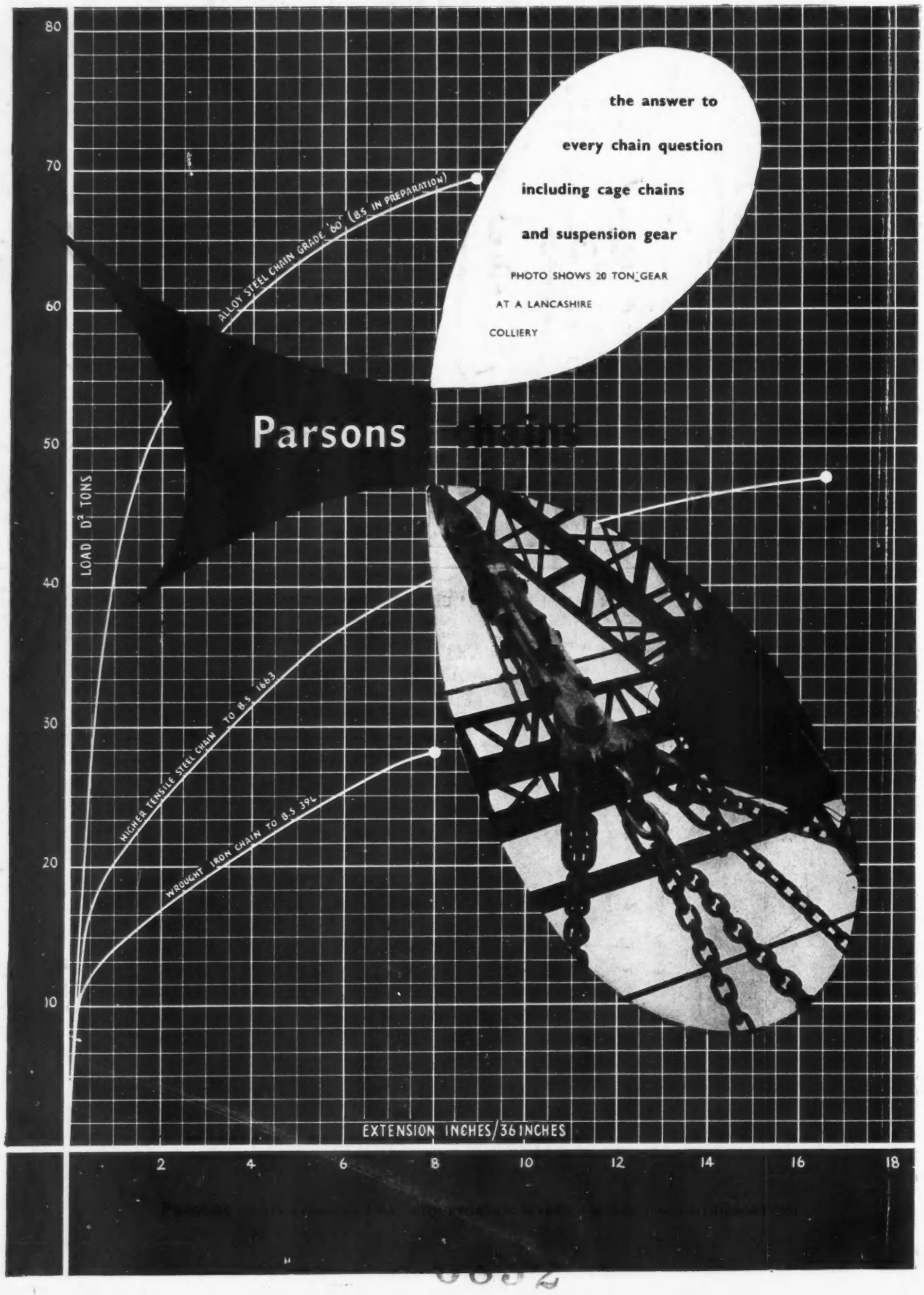
The Engineer

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